



Exploration & Production

GENERAL SPECIFICATION

PIPELINES - RISERS

GS PLR 100

Submarine pipeline systems

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1. Scope

This General Specification is applicable to the pre-project, the basic engineering, and the construction engineering of the Submarine Pipeline Systems.

It can also be used in the view of a requalification project as defined in section 28.

The Submarine Pipeline System(s) are further on referred as **the SYSTEM(s)** - see definition in section 3.2.

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.

Prime References

The **Prime References** are those of the reference documents which are - by destination - covering the entire scope of the design of **the SYSTEMS**.

The **Prime References** are identified with a **(PR)** mark-up in the following lists of the reference documents.

The section 10 is specifying the conditions of the use of the **Prime References** in conjunction with this General Specification.

Standards

Reference	Title
DNV OS F101	(PR) Offshore Standard - Submarine pipeline systems
DNV OS F201	(PR) Offshore Standard - Dynamic risers
ANSI/ASME B31.4	(PR) Pipeline transportation systems for liquid hydrocarbons and other liquids
ANSI/ASME B31.8	(PR) Gas transmission and distribution piping systems
ASME III	Nuclear Power Plant Components
ASME VIII	Rules For Construction of Pressure Vessels
ASME B16.20	Metallic Gaskets for Pipe Flanges

Professional Documents

Reference	Title
DNV 1981	(PR) Rules for submarine pipeline systems
API RP 1111	(PR) Design, construction, operation and maintenance of offshore hydrocarbon pipelines (limit state design)
API RP 2RD	(PR) Design of risers for floating production systems (FPSs) and Tension-Leg Platforms (TLPs)
ISO 13623	(PR) Petroleum and natural gas industries - pipeline transportation systems
ISO 16708	(PR) Petroleum and natural gas industries - pipelines transportation systems - reliability based state methods
DNV RP F104	Mechanical pipeline couplings
DNV RP F105	Free spanning pipelines
API 17B	Recommended Practice for Flexible pipe
API 17J	Specification for Unbonded flexible pipe
ISO 13628	Subsea Production Systems - parts 1 to 9
ICPC - n°.3 - issue 7	Criteria to be Applied to Proposed Crossings Between Submarine Telecommunications Cables and Pipelines/Power Cables.
InSpec JIP 1.1.4.140 / RP01	Recommended Practice for Insulation and Buoyancy Systems - rev 1 - July 2002
InSpec JIP 1.1.4.140 / SP01	Specification for Insulation and Buoyancy Materials - rev 3 - October 2002

Regulations

Where Local (national, international) regulations and rules exist, their provisions and those of the standards and codes to which they refer shall have precedence over the prescriptions of this General Specification.

Reference	Title
Not applicable	

Codes

Reference	Title
NEN 3650	Requirements for steel pipeline transportation system (Dutch code)
BS 8010	Code of Practice for Pipelines (Part 3)

Other documents

Reference	Title
Not applicable	



Total General Specifications

The list of the Total General Specifications in relation with the design, fabrication, installation and precommissioning of **the SYSTEMS** is separately provided in the **GS PLR 000**.

The Total General Specifications that are of direct use for **the SYSTEMS** are provided in the **GS PLR 000**.

The organisation and documentation systems to be put in place for **the DESIGN** are separately covered in the **GS PLR 002** and **GS PLR 001**, respectively.

Reference	Title
GS PLR 000	General Specification Catalogue
GS PLR 001	Documentation requirements
GS PLR 002	Organisation of the design works
GS PLR 107	Design and Construction of Pipelines in Swamp and Marsh Areas
GS PLR 109	Design, fabrication and testing of submarine unbonded flexible pipes and risers
GS PLR 111	Submarine bundles
GS PLR 151	Design of steel catenary riser systems
GS PLR 401	Installation of submarine pipelines
GS PLR 409	Installation of submarine cables, umbilicals and flexible pipes
GS EXP 101	Precommissioning & Commissioning Guidelines
GS EXP 103	Precommissioning & Commissioning Technical Preparation
GS EXP 105	Precommissioning Execution

3. Definitions and abbreviations

3.1 Definitions

The DESIGN	Means the design of the SYSTEM , either of conceptual, pre-project, FEED, or detailed type.
The SYSTEM	Means a submarine pipeline system comprised between one single entry point and one single delivery point; so that anyother tied-back pipelines shall be treated as other individual SYSTEMS . Refer also to section 4.
Alternative(s)	Means any Alternatives that can be proposed in the frame of the DESIGN , whenever clearly identified in the course of this General Specification. See section 10 for specific requirements.
Third Party	Means a Certifying Authority, or a Classification Authority, or an independant company in charge of any independent design review, appraisal, or analysis.
Battery Limits	Means either terminations of the SYSTEM , as specified by the General Basis of the Design (see 9).

Component Means any permanent or temporary component incorporated in **the SYSTEM(s)**, as necessary for its construction and operation. See list of components in section 3.2.

3.2 Abbreviations

ALARP	As Low As Reasonably Possible	MAOP	Maximum Allowable Operating Pressure
AP	Abnormal Pressure	MOP	Maximum Operating Pressure
APR	Applicable Prime Reference(s)	MoU	Memorandum of Understanding
BL	Battery Limit	OD	Outer Diameter
CBA	Cost Benefit Analysis	PLL	Potential Loss of Life
DCS	Distributed Control System	QRA	Quantified Risk Analysis
DP	Design Pressure	ROV/ROT	Remote Operated Vehicle/Tool
ESDV	Emergency Shut Down Valve	SCADA	Supervisory Control And Data Acquisition
FPU	Floating Production Unit	SMYS	Specified Minimum Yield Stress
HAT	Highest Astronomical Tide	SPS	Subsea Production System
HIPPS	High Integrity Pressure Protection System	SRA	Structural Reliability Analysis
ICAF	Implied Costs of Averting a Fatality	SSIV	Subsea Safety Isolation Valve
ID	Internal Diameter	TDZ	Touch Down Zone
IR&M	Inspection, Repair, & Maintenance	UHB/LB	UpHeaval Buckling and/or Lateral Buckling
IRPA	Individual Risk Per Annum	VIV	Vortex Induced Vibration
LAT	Lowest Astronomical Tide	WSD	Working Stress Design
LRFD	Load Resistance Factor Design	WT	Wall Thickness

4. The SYSTEM

4.1 Scope

The SYSTEM shall consist of a single entry point and single delivery point of a submarine pipeline and any other tied-back pipelines shall be considered as other individual **SYSTEMS**.

The Appendix 1 is providing an overview of the main typical **SYSTEMS** in the frame of this General Specification.

Design of river crossings is not normally addressed by the **GS PLR 100**.

Design of pipelines in swamp and marsh areas is specifically addressed by the **GS PLR 107**.

Specific design of safety systems such as HIPPS, DCS, and SCADA is not covered by this General Specification.

Additional scope and requirements are provided in the following.

4.2 Conveyed fluids

Conveyed fluid shall only be either a crude oil, or a stabilised oil, or a commercial oil, or a rough gas, or a treated gas or gas condensate (stabilised or not) or an injection water, or treated water, or methanol, or a glycol.

4.3 Main components

The SYSTEMS are those exclusively of welded assemblies of carbon steel or equivalent line pipe, with possible adjunctions of non-bonded flexible strings such as for risers and subsea connecting spools.

Non-bonded flexible sections incorporated into or fully making **the SYSTEM** shall be compliant with the **GS PLR 109**.

For corrosion resistant alloy or non-steel metal incorporated into or fully making the tubulars of **the SYSTEM**, the limitations outlined in section 25 shall be observed.

4.4 Bundles

Bundles shall be designed in compliance with the **GS PLR 111** and the individual pipelines being part of a bundle shall be individually designed in compliance with this General Specification.

Other lines entering the structure of a bundle shall be individually designed in compliance with their relevant Total General Specifications.

4.5 Export pipelines between FPU's

Currently, there are no professional documents, standards, codes, or Total General Specifications directly addressing these highly dynamic systems.

Until any such documents are available, the design requirements and methods shall be derived from those of the Prime References which are addressing the dynamic risers.

4.6 Other components

In addition to steel line pipes, the following components can be incorporated to form a complete submarine pipeline system:

- aerial and subsea valves of any type
- anodes (bracelets, bulks)
- blind flanges
- bulkheads (temporary, permanent)
- external concrete weight coating
- external corrosion coating
- external thermal insulation coating
- flanged connectors (swivel or not)
- flexjoints
- installation aids (temporary, permanent)
- insulating joints
- internal cladding, lining or coating (corrosion, flow drag reduction)
- mechanical connectors
- mechanical protectors (temporary, permanent)
- monitoring devices (temporary, permanent)
- pig traps
- piggy back straps
- pipeline end manifolds
- riser clamps (fixed or guided)
- ROV/ROT aids (temporary, permanent)
- slug catchers
- stabilising mattresses (anti-scour)
- mechanical protection devices
- stress joints, tapered joints
- supports (temporary, permanent)
- tappings, tees, and wyes
- VIV suppression devices

5. Battery Limits

The Battery Limits of **the SYSTEM** consist of the tie-in point to the host facilities at its either ends and they shall be treated as Interfaces in compliance with section 6.

By default, the BLs are located downstream the welded connection to the upstream ESDV and upstream the welded connection to the downstream ESDV.

In addition:

- the branch between the ESDV and the pig launcher or receiver shall be **preferably** part of **the SYSTEM**
- depending on the APR, slug catchers and pig traps can be either treated under a pressure vessel or a pipeline Prime Reference,
- depending on the conclusion of a dedicated risk analysis, the ESDV can or cannot be of flanged type.

6. Interfaces

The BLs are located at the main Interfaces.

Other Interfaces shall be created whenever there is a direct contact or a potential risk of contact between **the SYSTEM** and the surrounding existing facilities, soils, human activities, etc.

Both permanent and temporary Interfaces from the initiation of the construction phase until the end-of-life period shall be identified and sorted out.

Interfaces shall therefore be created at any points where there is:

- a significant disruption in the design conditions,
- especially at design code break points such as pipeline/piping, pipeline/riser, etc.
- a significant change in the behaviour of the interfaced sections, such as loadings, flowing, thermal behaviour, etc.

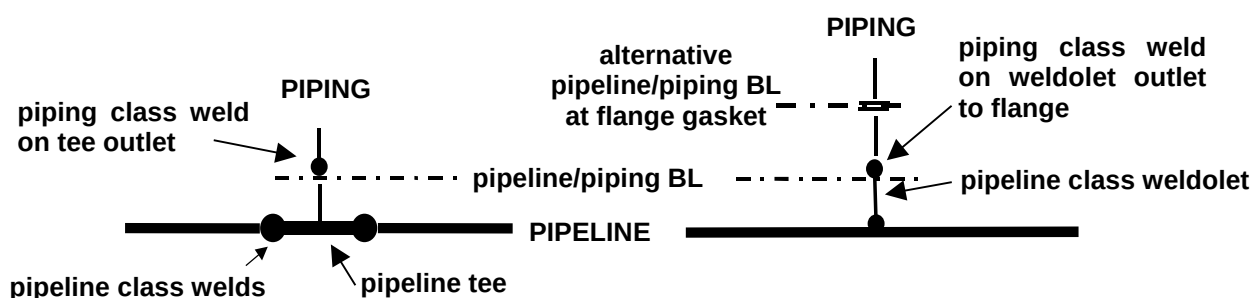
Interfaces shall be thoroughly and timely resolved, especially when other works are involved.

The design of an interface shall not impair the safety and the functional requirements of the interfaced sections or facilities.

The envelopes of the acceptable design parameters of the interfaced systems, sub-systems, components shall be part of the Design Basis (see 9).

The interaction analysis shall be fully documented with an outline of the safety margins with respect to the Prime References applicable to either interfaced systems.

The following scheme provides two typical examples of pipeline/piping interfaces:



7. Organisation of the DESIGN

The organisation of **the DESIGN** shall as a minimum conform to the [GS PLR 002](#).

8. Deliverables

The documentation to be produced in the frame of **the DESIGN** shall as a minimum comply with the [GS PLR 001](#).

9. Design Basis

The format and the organisation of the design data shall comply with the requirements and principles stated in Appendix 2 and in the [GS PLR 001](#).

The available design data shall be sufficient and consistent for **the DESIGN** and that their respective uncertainty levels are consistent with the required level of accuracy for **the DESIGN**.

The use of values "by default" (i.e. hydrodynamic coefficients, soil friction factors, etc.) is not permitted.

Additional working hypotheses shall be implemented and approved before any uses; as such, interpolation and extrapolation methods addressing the use of the design data shall be treated as **Alternatives**.

10. Applicable Prime Reference (APR)

If the APR is not stipulated by the CONTRACT, **the DESIGN** shall commence with the recommendation for the APR, that shall result from a sound comparison study of the various relevant Prime References.

When the complexity of **the SYSTEM** requires **more than one** APR, any potential conflicts shall be identified and resolved at the earliest stage of **the DESIGN**, and in compliance with the project goals.

Partial uses of other Prime References is allowed when the APR are silent on specific matters and potential inconsistencies as of these uses shall be timely resolved.

11. Alternatives

The use of **Alternatives** is only possible whenever specifically identified as such in the course of this General Specification.

Alternatives do not concern the requirements from the Regulations in force whenever these documents are contradicting this General Specification.

Alternatives shall:

- be proposed as soon as this General Specification addressed requirement cannot be fulfilled either for safety, technical, or economical reasons,
- be supported by sound documentation that shall:
 - reflects their adequacy with respect to the CONTRACT , and especially with the set functional requirements (see 12.2),
 - clearly establish their benefits and drawbacks as compared to the corresponding base cases of this General Specification,
 - be worked out on the basis of measurable elements.
- be fully approved before entering the design process.

12. Design requirements and principles

12.1 Scope

This section is outlining the design principles which shall be used for **the DESIGN** and based on which the **Design Plan** shall be implemented as per the **GS PLR 002**.

12.2 Functional requirements

As a minimum, the following main functional requirements shall be addressed:

- flow assurance, thermal management,
- mechanical strength (assembly, laying, in-place),
- IR&M
- retrievability/replaceability of critical components.

12.3 Criticality assessment

The criticality of **the SYSTEM** shall be assessed and the findings shall be ranked by measurable impacts on **the DESIGN**.

The criticality may involve specific conditions such as but not limited to:

- stringent Local Regulations
- severe flow assurance and/or thermal management requirements
- severe flowing condition (high pressure + high temperature, souring,)
- severe and/or poorly assessed environmental conditions
- very constricted area
- stringent interface condition, especially with a host facility owned by others
- simultaneous site works and field operations
- need of non fully industrially proven technology
- time history of an existing **SYSTEM**, under requalification process

12.4 Risk assessment

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

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.

12.5 Design Format

The WSD and the LRFD are the most currently used design formats, but the SRA may be also applied as an **Alternative** to the LRFD.

The selection of the design format shall be done according to the following principles:

- At a conceptual level, it should not be necessary to involve the LRFD format
- The choice between WSD and LRFD shall be supported by a comparison study that shall be done at the earliest phases of **the DESIGN**.
- Calibrated factors are provided by LRFD based Prime References, but **Alternatives** can be proposed based on designer's experience (see 12.6).
- The SRA may be applied as an alternative to the LRFD; the use of SRA shall follow the conditions stipulated in [DNV OS F101](#) - Section 5 - C 600.

The Total General Specifications that address the linepipe and fittings are consistent with the Prime References based on a WSD format, but potential conflicts because of LRFD based ones shall be carefully investigated before any further step.

12.6 Designer's experience

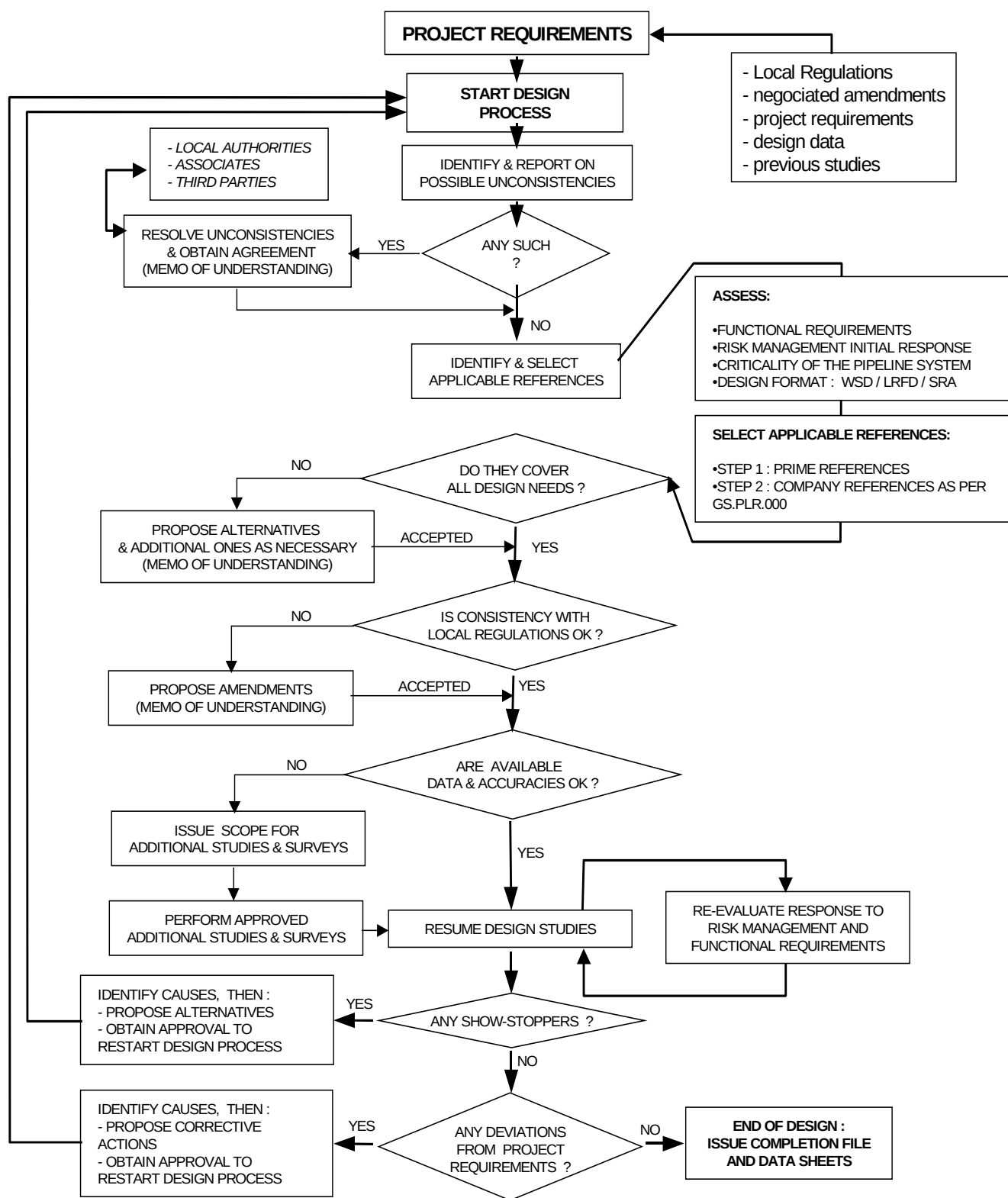
Designer's experience shall be treated as **Alternatives**.

Designer's experience can be of essence in areas such as but not limited to:

- concepts,
- refined analysis or qualification methods,
- materials, components or sub-systems, either of temporary or permanent nature,
- installation methods,
- inspection, maintenance, repair methods etc.

12.7 Design roadmap

The following design roadmap shall serve as a general guidance for the preparation of the Design Plan.



13. Flow assurance and thermal management

The flow management and thermal assurance design shall address the following issues, as applicable:

- the hydrate and/or paraffin formation prevention methods during shutdown phases as well as normal in-service conditions
- the surge pressure during shut-down
- inhibition or insulation requirements to prevent wax or hydrates deposition
- the effect of flow conditions on the efficiency of corrosion inhibitors, liquid catching and slug control requirements
- the inlet and delivery pressure and temperature envelopes
- the flow velocity (see Note below)

The **DESIGN** shall include an assessment of the following potential effects:

- cross-sectional design changes driven by installation and/or in-place constraints,
- routing issues in terms of the bathymetrical profile, such as local low/high points, overall slope, and roughness of profile,
- elevation layout of dynamic risers and bottom spools,
- minimum and maximum acceptable velocities, given the nature and properties of the conveyed fluids

A final hydraulic and thermal analysis shall be performed in the view of delivering:

- the accurate flowing conditions, with local effects such as liquid hold-up, hydrate and/or wax formation conditions, cooling effects, cooldown and warm-up times,
- the accurate stress, strain and displacements along the Pipeline System and especially at the interfaces with other facilities.

This analysis shall also demonstrate the adequacy with the Functional Requirements.

Note : the minimum velocity for an oil pipeline should not be less than 1 m/s and the maximum velocity for a gas pipeline should not exceed 15 m/s.

14. Route selection and surveys

14.1 Base case routing

It shall be initially confirmed that the available information is sufficient enough to elaborate on the base case routing(s). Other routes can be proposed, as **Alternatives**.

The routing studies shall culminate with a sound assessment of the critical findings in the view of supporting the selection of the installation means, the specification of the site preparation works, and the elaboration of the installation procedures.

14.2 Design principles

The following principles shall be addressed and ranked by order of criticality, in order to resolve any potential conflicts that may arise in the course of the routing studies:

- the features which shall be considered are as a minimum:
 - the general sea and soil conditions,
 - the flow assurance functional requirements,
 - the existing and future permanent and temporary facilities,
 - the sea traffic and fishing lanes,
 - the bottom-tow corridors,
 - the restricted areas,
 - the current site works at the envisioned installation date,
 - the installation and in-service risks within the envisioned routes,
- as far as practicable, the route shall be as close as possible to the perpendicular to the bathymetric lines,
- crossing of an unstable soil area shall be avoided, unless it can be proven that the safety of the pipeline system is not impaired,
- the bottom-tow corridors shall be identified as necessary, and a ranking method shall be implemented by comparing the advantages and drawbacks of the proposed corridors,
- existing bottom-tow corridors shall not be obstructed by the pipeline route, unless otherwise instructed,
- provisions for future developments such as branches for future tie-ins, corridor allowances, access to termination facilities, etc. shall be cleared up as soon as possible,
- the provisions for temporary and permanent access for drilling and workover rigs shall be fully documented,
- the horizontal separation between **the SYSTEM** and the nearest parallel line shall be at least of 50 m, as far as practicable,
- platform and subsea facility tie-ins shall consider a minimum horizontal separation distance of 5 m between **the SYSTEM** and the other lines that reach these facilities,
- the pipelines and cables crossing design shall be in accordance with Section 23,
- the curvature radii shall result in equivalent stresses that shall not exceed 10% of SMYS,
- the curvature radii shall not impair the in-place stability of the pipeline,

14.3 Surveys

The technical scope of the route surveys shall be elaborated in compliance with the relevant Total General Specifications.

This scope shall cover the geotechnical, geophysical and the other issues such as but not limited to the survey of debris, the subsea positioning, the foundations, etc.

The initial routing assessment shall be performed from available information without necessitating any additional site surveys.

When shore pulling method is envisioned, the site surveys shall also cover the concerned onshore areas.

Further routing assessment steps shall involve the preparation of the scope of surveys as necessary for the definition, preparation and execution of the detailed surveys to be performed,



with due consideration of allowances for any final routing adjustments, given outstanding survey findings and uncertainties on the installation methods.

15. Pipeline diameter

A Nominal Diameter shall be specified for **the SYSTEM** which shall be either of **constant ID** or of **constant OD** and the discrimination process between either modes shall be elaborated and the recommended mode shall be approved before any further action is taken.

The whole decision making process is generally involving a life-cycle technical and economical assessment, addressing the following issues, as a minimum:

constant ID: availability of line pipe of non standard diameter and/or wall thickness.

constant OD: capabilities of inspection/instrumented pigs when the Pipeline System is made of more than one wall thickness.

16. Pressure levels

16.1 Scope

Wide ranges of specified pressure levels are proposed in the Prime References and in many instances, an identical wording is implying different acceptations.

Hence, for the sake of clarity and especially in the selection process of the APR, specific pressure levels are provided and further on defined in paragraph 16.2.

This is especially relevant when **the DESIGN** shall involve more than one APR.

A Company approved MoU shall explain how these pressure levels shall be put face to face with the specified levels of the APR and the approved MoU shall be part of the General Basis of Design.

16.2 Definitions

These definitions shall be specified for the worst cases along the service life of **the SYSTEM**.

The last column specifies the maximum allowable stress ratio in association with the specified pressure level, with respect to the SMYS.

The set ratios are derived from the most current design practices, but other ratios may be relevant to comply with the APR.

Definition	Maximum stress
MOP Maximum Operating Pressure means the highest pressure along the service life, under normal operating conditions, inclusive pressure surges from slug flows, normal operation of valves, pumps and compressors, etc ...	72 % (a)
AP Abnormal Pressure means the highest likely pressure above the MOP and along the service life, having an annual frequency of occurrence in the range of 10^{-4} to 10^{-3} , such as from a malfunction of overpressure protection system.	90 % (b)
DP Design Pressure means the pressure at which the DESIGN shall be performed. The safest case is when the DP equates the AP. At lower DP values, a risk assessment shall be performed and concluded with risk mitigation measures.	72 % (a)
MAOP Maximum Allowable Operating Pressure means the internal pressure that shall not be exceeded under normal operating conditions; the MAOP can exceed the DP provided it will not generate an unacceptable loading in combination with the other sources of loading but in any cases, the MAOP shall remain below the AP. See note (c).	72 % (a)
Notes (a) is the maximum allowable hoop stress ratio (b) is the maximum allowable hoop stress, longitudinal stress and combined stress ratios, respectively, under functional loads only. (c) in certain instances, such as when the WT is driven by the pipelaying condition rather than by the pressure containment, it can be of interest to appraise the MAOP and to derive the hydrotest pressure from this MAOP.	

17. Subsea Safety Isolation Valves

The assessment of the need for SSIV - especially for gas pipeline systems - shall involve as a minimum the following procedure:

- (1) identify as a minimum the flowrate, the sour severity, the flow temperature and pressure, the ID, the water depths, the type of risers, the interfaces, and the lengths of each section of **the SYSTEM**
- (2) identify potential hazards to **the SYSTEM** and the hydrocarbon release mechanisms
- (3) identify measures to minimise the occurrence of hydrocarbon releases from the Pipeline System
- (4) perform Consequence Analysis to model jet and pool fires and to determine potential impact on the facilities
- (5) perform QRA based on event trees to determine:



- the PLL
 - the IRPA to personnel
 - the probability of installation loss
 - the pollution risks
 - probabilities of hazard events and failure of protection systems shall be built into the QRA
- (6) compare QRA results versus the established risk acceptance criteria for the SYSTEM, on each of the consequences on human, environment, and assets
- (7) depending on this comparison, implement improvements to lower risks to an acceptable level, and within the economical goals set for **the SYSTEM**
- (8) if necessary, perform CBA, and ICAF or equivalent concept, to determine the need of a SSIV or alternative protections
- (9) review the previous steps and prepare recommendations on whether to install a SSIV or to provide alternative protection and mitigation measures.

A decision tree and/or matrix case based on the lead factors as per above (1) shall be implemented in order to facilitate the decision making process and in addition, the following principles shall also serve as guidelines along this process:

- address the impact of piggability requirements on design and operational criteria of SSIVs,
- evaluate the need of permanent / temporary mechanical protections against impact,
- locate SSIVs so as to minimise the inventories between them and the topsides (i.e. the larger the water depth, the larger the inventory with mud line SSIVs),
- avoid use of check valves since they do not usually guarantee full tightness against reverse flow (however, this technology is expected to improve rapidly),
- address access for inspection, maintenance and repair,

The risks of not having an SSIV can be reduced to an ALARP level, provided these non exhaustive criteria are addressed in the course of the design studies:

- avoid clashing occurrence, such as from dynamic risers,
- evaluate needs and design of riser and ESDV protection against impact,
- improve fatigue life design,
- consider in-service monitoring of critical areas
- implement dedicated high inspection level of flexjoints
- implement passive fire protection, where needed.

18. Loads

18.1 Scope

The APR shall cover the entire types of loads.

In addition and at an initial response level **only**, the following principles shall apply, as a minimum.

18.2 Hydrodynamic loads

In the absence of enough accurate site data, the following shall as a minimum be obtained as necessary to derive the hydrodynamic loads from the MORISSON's equation:

- the 1 year and 100 year return periods,
- the design waves and winds for the eight main directions,
- the elevation profile of the current, with directional distribution, if available

In the lack of further requirement, a 50 mm (2") thick marine growth shall be considered for the splash zone (from HAT down to LAT) and for the first 15 m of water underneath LAT level.

For very early analysis steps only, the following values by default can be used: drag coefficient = 0.7, lift coefficient = 0.9, inertia coefficient = 3.29.

18.3 Seabed conditions

At an initial response level:

- representing the pipeline as a continuous foundation according to the TERZAGHI method shall suffice.
- in the absence of accurate soil data and/or accurate predictive soil-pipeline interface behaviour (short-term, long-term), the largest ranges of expected values shall be extrapolated (see section 9) from known data on sites of similar types,
- if this cannot be done, a lateral pipeline/soil friction factor of 0.7 together with a longitudinal one of 0.5 can be used by default and lower values by default are not permitted.

At further design steps:

- an accurate representation of the soil condition shall be fully implemented from the General Basis of the Design and then from any further site surveys in the frame of the CONTRACT.

19. Strength assessment

19.1 Scope

This section is mainly addressing the static sections of **the SYSTEM**.

Dynamic sections of **the SYSTEM** shall in addition comply with the **GS PLR 109** and **GS PLR 151**, as relevant, and these references shall have precedence on this General Specification on specific issues such as but not limited to local buckling and propagation buckling.

19.2 Pressure containment

The resistance to the internal pressure shall be engineered with due consideration of the principles stated in previous section 16.

As soon as the wall thickness of any section of **the SYSTEM** turns to be governed by the hydrotesting pressure rather than the operating pressure,

Alternative site acceptance test methods (see 27.4) shall be investigated as early as possible in order not to unduly oversize **the SYSTEM**.

19.3 Maximum external overpressure

The maximum external overpressure at a **given location** is the positive difference between the external hydrostatic pressure and the minimum internal pressure seen along the assembly, installation and service life of **the SYSTEM**.

The minimum internal pressure shall be the atmospheric pressure but as an **Alternative**, it can be found more efficient along **the DESIGN** to consider a partial or full pressurisation of **the SYSTEM** - or any parts of it - and in such an instance:

- at any time along the installation and service life of **the SYSTEM**, the internal pressure shall never drop down below the set pressurisation level
- the design checks set in the following 19.4 to 19.7 shall be based on the set pressurisation level.

19.4 Local buckling

The definition and the evaluation method for Lateral Buckling shall comply with the [DNV OS F101](#).

Unless otherwise specified, the local buckling analysis method shall comply with the [API RP 1111](#). However, the [DNV OS F101](#) shall be used for issues not captured by [API RP 1111](#) such as, but not limited to:

- Buckling due to combined bending and external pressure of UOE pipes
- Effect of ovality on the pipe collapse resistance, under external pressure alone.

In addition, the following criterion shall be satisfied:

- system collapse under external pressure, alone
- combined loading criteria under all the acting loads

As soon as the buckling load is found to exceed the combined adverse loads, UHB/LB shall be thoroughly assessed and relevant preservation/mitigation measures shall be engineered, as necessary.

Only widely validated predictive methods - based on observations made on existing pipelines and on accurate imperfection modelling - shall be used.

When significant axial compression - such as from large thermal expansion, uneven seabed, curved route - is essential to mechanical equilibrium, the equivalent stress criterion shall be used and the equivalent stress shall not exceed 10% of the SMYS.

19.5 Propagation buckling

The propagation buckling pressure shall be determined as per power-law type formula, with power-law exponent and factor, and safety factor against propagation buckling as per the APR.

This pressure level shall then be compared to the difference between the hydrostatic pressure at the concerned waterdepth and the minimum specified internal pressure, that is the atmospheric pressure, in almost every instances.

Any requirements such as increased linepipe wall thickness and buckle arrestors shall be assessed.

Arrestor shape and size shall be determined by a documented and validated calculation method.

Buckle arrestors should preferably be integral parts of the pipeline.

19.6 Fatigue assessment

The fatigue assessment shall be performed in any cases and it shall address any sources of fatigue from the very beginning of the construction phase until the end-of-life date, and especially the thermal cycling.

For requalification projects, the time history of **the SYSTEM** shall also be established so as to derive the cumulated damage and the residual fatigue life.

The selection of the applicable S-N curves shall be fully justified and documented, and segregated per:

- the relevant fluid (internal, external) properties (compositions, souring level, temperature)
- the addressed zone (current section, welds,)

19.7 Steel grade and wall thickness selection

The steel pipe WT and grade shall be based on a combined pressure containment, collapse/local buckling and buckling propagation assessment, for the installation and in-service conditions.

Consequences from a low WT design shall be accurately assessed and mitigated by steadily increasing the WT until an acceptable design is obtained. This especially addresses the pipelaying issues.

The selected design may dictate the line pipe process fabrication (Spiral, UOE, ERW, etc.) and assembly methods and in this event, these issues shall be timely cleared up .

For sections of pipeline and for rigid risers on fixed offshore structures, the other mechanical effects shall only be mitigated by improving the local configuration of the pipeline system, but not by changing the combined WT and steel grade selected.

For sections that are largely dominated by dynamical behaviour and subsequent fatigue, the adjustment of the riser configuration may not suffice and benefits of change in the WT shall also be investigated.

20. In-place behaviour

20.1 Scope

An overall assessment shall be performed, which shall include:

- the in-place lateral and vertical stability under direct hydrodynamic effects,
- a global riser clashing assessment shall be performed in compliance with the APR and also with the **GS PLR 151**; this assessment shall encompass any risers that are deemed to interfere with that of **the SYSTEM**.

At the end of this process, end expansions and loads as well as UHB/LB shall be re-assessed, as necessary.

20.2 On-bottom stability

20.2.1 Initial response

The initial response shall strictly comply with the following method, whatever the assessment method for the hydrodynamic loads and for the soil/pipeline interface response, but excluding the breaking wave zone which shall be treated separately:

- a minimum stability factor of 1.1 shall be satisfied under the most stringent installation or in-service condition,
- in case of UHB risk, a stability safety factor of 1.5 shall be targeted,
- a series of calibration curves shall be determined in the view of the initial response for the on-bottom stability design:
 - there shall be as many calibration curves as necessitated since of the variations in the design waves and currents, in the bathymetry, in the in-plane pipeline orientation, and in the pipe WT, along the route
 - the calibration curves shall cover the largest possible range of in-place concrete weighting densities, as such extreme calibration values shall be of 2.2 and 3.2
 - the theoretical concrete thickness profile along the route shall be generated for the required safety factor at each one of the two calibration densities
- the resulting curves shall serve as a baseline for the assessment of the theoretical concrete thickness at any intermediate in-place concrete densities, until the selection process of the concrete thickness and density is achieved,
- to this aim the following principles shall be addressed:
 - there shall be only one specified concrete density along the route
 - the amount of generated changes in the outer diameter of the pipeline shall be minimised and as a guidance, three changes are considered as a still acceptable value inclusive of any non-concrete coated sections
 - however, the above guidance may not be relevant when landfalls and UHB/LB are expected
 - the discretisation of the concrete thickness profile shall be optimised in order to match as far as possible any changes in the wall thickness of the pipeline
 - the selected concrete density shall also concur at optimising the total weight amount of in-place concrete as well as the overall economy of the weighting
 - on selecting a specified concrete density, the corresponding continuous concrete thickness profile shall be linearly interpolated from the calibration profiles before entering the discretisation process.

At the end of this process, the specified concrete coating thickness profile along the route shall:

- be at least the theoretical thickness at the specified concrete density,
- be always comprised in the range of 50 mm to 150 mm (2" to 6"),
- aim at keeping the number of thickness changes below four (4),
- aim at keeping the lowest possible concrete density within its calibration range (2.2-3.4), since of the high cost impact of the heavy aggregates

When the theoretical concrete thickness exceeds 150 mm, additional stability shall be processed by other methods such as trenching, covering, increased WT, etc.

When the theoretical concrete thickness is found significantly less than 50 mm, an economical comparison study shall be performed between:

- a 50 mm concrete coating at the lowest feasible concrete density (2.3, typically)
- and the minimum linepipe wall thickness that achieves a 1.1 safety factor

Discontinuous stabilisation is only allowed when it can be demonstrated that the long term settlement of these components will not impair the stability and mechanical resistance of the pipeline.

As soon as the specific gravity of the waterfilled pipeline is beyond that of the soil, it shall be checked that the settlement of the pipeline does not lead to a significant vertical deformation.

A summary graphical representation of the overall process shall be established, showing along the entire route:

- the two concrete thickness calibration profiles (upper and lower bounds wrt concrete density range)
- the concrete thickness theoretical profile at the specified concrete density,
- the derived specified wall thickness profile,
- and the other stabilisation means.

20.2.2 Detailed design

The concrete coating specification as well as the specified other stabilisation measures shall be checked against refined stability analysis methods such as VERITEC's RP E305 or equivalent methods, and based on the most accurate available data.

Alternative concrete coating specification and other stabilisation measures shall only be engineered:

- if they provide at least the same stability safety factor, without impairing the other issues such as UHB/LB, etc.
- and only if they result in an optimised life-cycle design, technically and economically wise.

20.3 Freespanning

20.3.1 Initial response

The maximum allowable freespans shall be derived from the static, dynamic and fatigue analyses that shall be performed in compliance with the **DNV RP F105**, and under the laying, hydrotesting, new in operation, and corroded in operation conditions, respectively.

On assessing the maximum allowable freespans along **the SYSTEM**, it shall be clearly demonstrated that the assessment process is aiming at minimising the freespan reduction works, hence at maximising the allowable lengths.

The potential positive impact from short and long term settlements shall be investigated along **the SYSTEM**:

- either from accurate soil data,

- or from known time history of pipelines of similar size and weight in the vicinity of **the SYSTEM**, and in this case, this shall be treated as an extrapolation (see 9).

At the end of this process, and based on the most accurate available survey data:

- freespans below the maximum allowable value shall be marked-up as "acceptable"
- freespans above 1.3 times the maximum allowable value shall be marked-up as "reduction required"
- freespans comprised between the maximum allowable value and 1.3 times this value shall be marked-up as "to be re-assessed"

20.3.2 Re-assessment

Re-assessment shall be required for freespans that have been marked-up as such, and also at every occurrence of more accurate surveys or new meteo oceano environmental conditions, and inclusive of the as-laid survey.

Freespans marked-up as "to be re-assessed" shall involve a dedicated site survey that shall be performed within the frame of the installation works and that shall result in an acceptance status or in the specification of the reduction works, as necessary.

In no cases a re-assessed allowable freespan length shall be shorter than that from the initial response.

20.4 End expansions and loads

The end expansions and loads shall involve an interface design process in compliance with the previous section 6.

The end expansions and loads shall be thoroughly derived from the most constraining pressure and temperature profiles.

The initial response shall consist of a graphical representation demonstrating the increase of the axial load induced at the concerned BL when the axial expansion decreases from the free end condition to the fully restrained one.

The stiffness matrix at the interface shall be derived from a combined modelling of the interfaced systems, taking into account the lengthes of influence of either interfaced systems.

This representation shall serve as a guideline for the selection of the tie-in design method, in conjunction with the load and displacement capabilities of the connected facility.

Further detailed checks shall involve accurate 3D models taking into account the appraised designs of the interfacing systems.

The induced loads and displacements of the interfaced facilities shall remain below their respective boundary values.

In this view, additional steel pipe or flexible pipe spool shall be engineered as necessary, but **Alternatives** can be proposed.

20.5 Additional protection

Additional protection may be required as a result of an accidental load impact assessment and such protection method can consist of:

- a trenched section, with or without backfilling (natural or artificial),

- an untrenched section of pipeline with a gravel dumping or mattress protection.

The assessment of the protection method shall demonstrate:

- that the protection will remain in place for the service life, especially under strong sea state and current conditions,
- that the generated compressive loads will remain acceptable, as per above 19.3
- that the protection will not prevent the expansion movements of expansion spools

At the installation phase, fluidised soil density shall be determined using ATTERBERG's liquid limit, and the specific gravity of the pipeline shall at least be 1.1 times the one of the fluidised soil.

The following can serve as a guidance along with the screening process of the trenching method:

Pipeline size	Soil	Trenching
OD > 24"	Sand	Pre-lay dredging
	Hard clay	Pre-lay jetting by crawler
OD < 24"	Sand	Post-lay ploughing
	Hard clay	Post-lay jetting or cutter crawler

21. Risers

21.1 Scope

The risers covered by this General Specification are:

- the steel risers on fixed offshore structures
- the flexible risers on fixed offshore structures, passing through I-tubes and J-tubes
- any types of riser connecting the on-bottom section of pipeline to a FPU.

21.2 Static risers

Static riser shall be made of continuous welded lengths of pipes without any intermediate flanged connections.

The use of flanged connections shall be compliant with the requirements set in sections 5 and 22.5, strictly.

Static riser during the platform design must be preferably positioned inside the jacket frames so as to improve the safety of the riser against the impact loads.

Platform movement as well as long term predictive soil modifications shall be included in the design basis.

The upper support clamp of the riser shall be treated as a main **Interface** which shall be an anchor point located at the top level of the platform's jacket

The upper support clamp shall as a minimum support the extreme weight load of the riser.

The upper support clamp should preferably consist of a forged body integrated in the riser body; as such it shall have the same internal diameter as that of the riser.

The intermediate clamps positioned along the platform shall be designed to allow the riser to move longitudinally.

The overall safety of **the SYSTEM** can be improved by adequately locating “fuse” supports of less resistance than the one of the riser and pipeline systems.

The expansion loop shall be part of the riser and therefore shall be designed with the same design factor as that of the vertical riser section.

21.3 Dynamic risers

Dynamic risers are those which are required for tie-ins of submarine pipelines to floating production and/or storage units. Such risers can be of steel or non-bonded flexible types.

Typical examples of dynamic risers are provided in the [DNV OS F201](#) and [API RP 2RD](#) references.

The design requirements for the dynamic non-bonded flexible risers and for the steel catenary risers are covered by the [GS PLR 109](#) and [GS PLR 151](#), respectively.

22. Tie-ins

22.1 Scope

The following tie-in methods are possible: flanged couplings, mechanical couplings, aerial welds, hyperbaric welds.

The design of a tie-in shall be engineered in compliance with the interface requirements set in previous sections 6 and 20.3.

In addition:

- a combined safety, technical and economical assessment shall be performed in order to derive the best appropriate tie-in method
- not only the main technical issues but also the logistical ones such as lack of local content, planning risk, etc., shall be thoroughly addressed
- the life-cycle assessment shall consider the benefits and disadvantages of each proposed method, and especially as compared to those of an hyperbaric weld
- unless very special circumstances, the only acceptable connection for an ESDV is by gold welds at either ends, which should require a top entry valve design for maintenance requirements and dedicated lifting devices, too
- other tie-ins shall be designed so as not to reduce the level of safety, reliability and efficiency of the pipeline system as well as that of the host facilities
- there shall not be more than two connections of non-welded types at either terminations of **the SYSTEM**
- material selection for flanges and mechanical couplings shall comply with section 25 requirements; however, in the case of a repair project, this last requirement may be waived and accordingly treated as **Alternatives**.

22.2 Location of tie-in points

If there is no major constraint on doing so - such as from flow assurance issues - the best preferred configuration for the connections of non-welded types is the Vertical Access.

The flanged and mechanical connections shall remain fully and permanently accessible to divers and/or ROVs; as such, protection by mattresses or trenching is not allowed.

22.3 Aerial welding

Aerial weldings shall be of gold weld type and shall comply with the relevant Total General Specification for the specified type of linepipe, souring severity, and welding process.

When the welded section has further on to be lowered down into the water, accurate strength analyses and installation procedures shall be elaborated.

22.4 Hyperbaric welding

As a minimum, the following minimum requirements shall apply:

Hyperbaric welding is suitable for all pipes, regardless of the size, and specifically recommended for gas pipeline tie-backs to manned platforms.

At an initial step, the studies shall demonstrate the feasibility and the reliability of the hyperbaric welding tie-in and shall evaluate the involved surface and subsea intervention means.

Then, the detail studies shall culminate at least with the safety, operational and contingency procedures as necessary for :

- the site preparation works,
- the alignment and preparation of the pipeline sections,
- the welding and quality control,
- the site restoration works.

22.5 Flanges

The use of flanges is limited to pipelines less than 18" in OD **together** with an MAOP less than 6 MPa, however irrespective of more stringent limitations that may result from the criticality assessment of **the SYSTEM**.

Other applications shall therefore be considered as **Alternatives**.

The design checks of the flanged connection shall be performed with due account of the equivalent pressure method as per the [ASME III](#) division 8 and the [ASME VIII](#) codes.

The flanged connection shall be fitted with a test port which shall be ROV accessible, and waterlockless, by design.

The need of a swivel flange shall be carefully investigated in terms of advantages and drawbacks.

Gaskets shall be of metallic ring-joint type in compliance with [ASME B16.20](#).

A new gasket shall be installed in place of the old one whenever the installation procedure has failed or is suspicious.

The bolting method will be selected in order to get a reliable, measurable and repetitive torque, tension or force. Use of flogging spanner is not allowed.

Extra-torque of the bolts is not permitted, especially so as to stop a flange leak.

Metallurgy of the flanges and design of gaskets shall be as per the relevant Total General Specifications.

Internal coating or cladding of flanges or any exotic arrangement shall be treated as **Alternatives**.

22.6 Mechanical couplings

Mechanical couplings for permanent uses shall at least provide the same level of reliability as that of a flanged connection.

In highly critical instances - such as large diameter with high pressure gas - the same level of reliability as that of a gold weld shall be obtained and such uses shall be treated as **Alternatives**.

The **DNV RP F104** shall preferably used in any cases, and strictly used under highly critical instances and especially when additional strong qualification is required.

23. Crossings

Crossings of pipelines, umbilicals and cables, shall be designed as such:

- the current condition of the crossed line shall be accurately assessed,
- stacked pipeline or cable crossing shall be avoided
- the crossing angle shall be at least of 30 degrees and as close as possible to the in-plane perpendicular,
- a minimum vertical watgap of 0.3 m shall be insured and maintained along the service life between the crossed line and the crossing one,
- the crossing design shall accommodate pipeline expansion effects,
- there shall be no interferences between the crossed line and the crossing one,
- the crossing of cables shall comply with the ICPC Recommendation No.3 Issue 7,
- crossing of a line not owned by the SYSTEM owner's shall be engineered under the other owner's requirements and any potential consequences on **the DESIGN** since of the observance of these requirements shall be identified and treated as **Alternatives**.
- crossings in the vicinity of a platform / a subsea facility shall be carefully assessed and there shall be no detrimental impact on the riser / the connecting spool of **the SYSTEM**.

24. Landfalls

For landfall analyses, the following additional documentation shall be implemented:

- the detailed route in the land fall zone,
- a design brief on the landfall construction methods, including the evaluation of the technical parameters, of the site preparation works (onshore, offshore), of the site restoration works, backfilling of trenches, etc.
- for a standard landfall using a laying barge, the critical data shall be determined; such are the required pull, pipe stresses, any lightening of the pipes required for laying, etc.

When pulling method is used, the pulling distance shall result from:

- the route selection, mostly perpendicular to bathymetric and shore lines
- the draught of the laying barge

- the water depth and sea bottom slope
- the pipe line negative buoyancy
- the winching maximum allowable capacity and tidal range.

As far as practicable, the assembly and pulling can be done together on the laying vessel, with a return pulley on the beach.

As an initial response only, the pulling load can be estimated as follows (this formula can easily be adapted for a pulling winch located on the layvessel) and the derived pulling load shall not exceed 3,000 kN.

$$F = f \times (W_s \times D_s + W_d \times D)$$

where

- f is the soil friction factor
- W_s is the submerged pipe weight
- D_s is the submerged distance
- W_d is the dry pipe weight
- D is the tidal distance plus beach width

25. Material requirements

25.1 Scope

The materials for the temporary and permanent components of the SYSTEM shall comply with the relevant Total General Specifications, as listed in the **GS PLR 000**.

The uses of any metallic and non-metallic materials that are not covered by any dedicated Total General Specifications shall be treated as critical **Alternatives**.

25.2 Metallic materials

The Total General Specifications are **exclusively** covering the uses of CS and C-Mn steel materials for sweet and for sour services.

25.3 Thermal insulation and Buoyancy materials

Whenever the thermal insulation and the buoyancy functions are together required, they shall be individually addressed in the light of their respective available solutions and impacts on **the DESIGN**.

The convergence of the thermal insulation and of the buoyancy designs shall only result from a sound comparative assessment that shall culminate with a decision matrix system.

Until an internationally recognised reference document is available (see note below), the selection and integration of materials for thermal insulation and buoyancy shall be performed in compliance with the following documents:

- "Recommended Practice for Insulation and Buoyancy Systems" - rev 1 - July 2002
- "Specification for Insulation and Buoyancy Materials" - rev 3 - October 2002

Note : these documents have been prepared by MCS on behalf of the participants in the InSpec JIP and they are currently being implemented in the forms of an API recommended practice and an API standard, respectively.

26. Installation

26.1 Scope

The installation studies shall demonstrate that **the SYSTEM** survives the installation loads and that the residual fatigue life remains acceptable with respect to the intended service life.

26.2 Initial response

The initial response shall provide enough information in the view of the selection process of the installation vessels and means.

Any plastic deformations induced by the assembly and installation processes shall be addressed in compliance with [DNV OS F101](#) Section 9.E as soon as they exceed the maximum values set in section 4.3.2 of the [DNV 1981](#), otherwise the [DNV 1981](#) reference remains acceptable.

Resulting changes in pipe geometry and material characteristics shall be determined and accounted for and a detailed documentation shall be provided.

Straightening devices shall be engineered and operated so as to ensure that pipeline straightness following the straightening activities satisfies the straightening criterion defined in the Total General Specifications addressing the fabrication and welding of the linepipes.

Contingency repair spares for the installation phase shall be estimated (spares for in-service repair works are covered by section 29).

26.3 Detailed studies

Once the installation vessel(s) is (are) nominated, the environmental limiting parameters beyond which each step of the assembly and laying operations shall be safely interrupted, as well as these below which the operations can be safely resumed, shall be clearly established.

This involves a full knowledge of the vessel(s) response to sea states, currents and winds and as such, capabilities of the following equipment shall be fully established:

- station keeping system,
- tensioning system capacity,
- stinger or equivalent system capacity,
- linepipe and components storage and assembly areas

Analyses under flooded pipeline as well as for empty condition shall be performed in order to further serve as an initial response in the case of a suspected or proven collapse during laying.

Contingency repair spares for the installation phase shall be detailed.

26.4 Limitations

The pipelay initiation by attachment to fixed or floating facilities as well as the free fall riser installation method can be **exceptionally** proposed as critical **Alternatives** and only if there is a **major** issue in not doing so, and the **Interface** issues shall therefore be thoroughly assessed.

27. Precommissioning

27.1 Scope

Precommissioning shall be engineered as specified in:

- **GS PLR 501** for hydrostatic testing of submarine pipelines.
- **GS PLR 502** for precommissioning of submarine gas pipelines.
- **GS EXP 101** Precommissioning & Commissioning Guidelines
- **GS EXP 103** Precommissioning & Commissioning Technical Preparation
- **GS EXP 105** Precommissioning Execution

Any conflicts and inconsistencies between the GS PLR and GS EXP series shall have been sorted out at the beginning of **the DESIGN**, and before any further action is taken.

Additional minimum requirements are provided in the following.

27.2 Hydrotesting

The hydrostatic test pressure shall be governed by the APR for the considered section of **the SYSTEM** (or for the entire **SYSTEM**, if a global hydrotest is acceptable).

When a global hydrotest is envisioned for a **SYSTEM** made of sections covered by different APRs, the hydrotest process shall be such that the hoop stress at the weakest point of **the SYSTEM** shall never exceed 90% of the SMYS and without inducing any deviation from anyone of the APR, otherwise, a sectional hydrotesting process shall be engineered.

The duration of the hydrostatic test shall be of 24 hours.

The air content shall not exceed 0.2% of the calculated capacity of the section of the **SYSTEM** under the hydrostatic test.

27.3 Leak tests

Whenever a tie-in by means of flanges or mechanical coupling is performed after the individual hydrotesting of each tied-in section, the tie-in shall be leak tested at a pressure level shall be not less than the local Accidental/Extreme Pressure (see 16.2).

27.4 Alternative site acceptance tests

Since the **DNV OS F101** section 5.B.203 waiver notice is not a currently field proven method, its use shall be considered as a critical **Alternative** that shall be subjected to an in depth assessment and qualification program which shall be documented at the initiation of **the DESIGN**.

27.5 Gauging

The consequences of an outer diameter based design of **the SYSTEM** shall have been investigated (see 15) and the minimum number of sectional gauging shall be specified together with the required diameter of each gauging plate.

The gauging plate diameter shall be at least 95% of the lowest ID along the concerned section of **the SYSTEM**, taking into account the worst combination of fabrication and assembly tolerances, and additional information shall be read in the **GS PLR 109**, **GS PLR 401**, **GS PLR 409**, and **GS PLR 502**, as relevant.

Deviations from these requirements shall be understood as **Alternatives**.

28. Re-qualification of an existing SYSTEM

28.1 Scope

This General Specification can be used in the view of a requalification project involving the studies, engineering and site works to be performed further to any significant changes undergone by **the SYSTEM** along its service life, such as:

- appraisal of environmental conditions,
- changes in the flow parameters,
- extended service life,
- recovery of a temporarily abandoned pipeline system,
- deterioration mechanisms beyond the initial assumptions,
- discovered damage, with pre- and post- repair assessments.

28.2 Corroded pipelines

At a preliminary assessment level, the following shall be adhered to:

- weight of pipe and axial stresses shall be calculated assuming the whole section uniformly corroded at 10% of the corrosion allowance.
- bending and hoop stresses shall be calculated assuming a local corrosion point at 100% of the corrosion allowance.

29. Repair Plan

29.1 Scope

The Repair Plan addressed by this section is only concerning the service life of **the SYSTEM** (the contingency repair spares for the installation phase are covered in section 25.1).

29.2 Implementation

Unless the Repair Plan is required by the CONTRACT, the need for a Repair Plan shall be duly established from the results of the criticality and risks assessments (see 12.3 and 12.4).

Unless its scope is fully specified in the CONTRACT, the scope shall be implemented according to the results of the criticality and risks assessments and shall as

The Repair Plan shall as a minimum:

- specify, qualify, and procure the allocated material and component take-offs, with the associated storage requirements
- specify the conditions of use of the allocated materials and components in the view of their preparation, inspection, conditioning, expediting, and incorporation in **the SYSTEM**
- specify the safety requirements that result from the above activities and also the safety requirements in the surroundings of the repair location,

- specify whether during the repair works the SYSTEM can be safely operated, or operated in a downgraded mode, or shut-down,
- provide an indication of the mobilisation and repair time duration as well as the operational limitations of their uses based on the known environmental conditions at the location of the repair works.

At further detailed levels, the Repair Plan shall be covered by an Emergency Response Plan that shall, as a minimum:

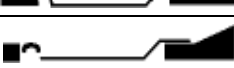
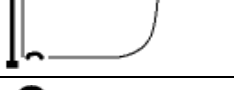
- provide an initial response plan to allow as necessary to:
 - characterise the proven or suspected damage
 - prepare for the mobilisation of the local and the foreign contractors
 - prepare for mobilisation of the detailed damage survey prior to repair
 - identify the need for a temporary repair or the relevancy of a permanent one
 - notify to the relevant addressees
- provide the minimum requirements as necessary to engineer the repair works:
 - mobilise the survey and repair contractors
 - perform the detailed surveys
 - perform the detailed engineering of the repair
 - update the time schedule of the repair works
 - procure any additional components and materials
 - qualify all the procedures and personnel for the repair works
 - notify to the relevant addresses
- provide the minimum requirements as necessary to perform the repair works, as such:
 - the site preparation works
 - the yard inspection, the conditioning and the expediting of the repair equipment, components and materials,
 - the preservation of the non damaged sections of **the SYSTEM**
 - the retrieval of the non recoverable parts of **the SYSTEM**
 - the repair works
 - the site acceptance test
 - the re-commissioning and start-up of **the SYSTEM**
 - the site restoration works
 - the demobilisation of the repair contractors
- provide the minimum requirements for the completion file of the repair works
- and in the case of a temporary repair, provide the maximum allowable operating condition of **the SYSTEM** until the permanent repair is achieved.



30. PLR Database

At the end of **the DESIGN**, the PLR Database shall have been thoroughly implemented in conformity with the **GS PLR 001** requirements.

Appendix 1 Typical submarine pipeline systems

LAYOUT	DESCRIPTION	MAIN USES
	steel pipeline with rigid risers connecting two fixed offshore platforms (*)	shallow water infield or interfield pipeline systems subsea unit may be a distant PLEM or a subsea wellhead manifold
	steel pipeline with one rigid riser and one jumper (steel or flexible) connecting one fixed offshore platform and one subsea facility (*)	
	steel pipeline with two jumpers (steel or flexible) connecting two subsea facilities (*)	typical subsea infield or interfield development configuration (shallow or deep water)
	steel pipeline with one rigid riser and one landing section connecting a fixed platform to an onshore facility	shallow water offshore field to onshore facility link in almost every cases, such applications do not involve any flexible components
	steel pipeline with one jumper (steel or flexible) and one landing section connecting a subsea unit to an onshore facility	
	steel submarine or underwater pipeline with two landing sections	crossing of water or seawater channels of significant depth and width; systems between onshore facilities, running alongside the coast as an alternate to a fully onshore route
	steel pipeline with two steel catenary risers connecting two floating facilities (*)	specific deepwater systems for normally permanent transfer of fluids between floating units (systems such as floating hoses for offloading are not covered here).
	connected floating facilities through multiple arch of steel pipeline with flexible jumpers at either ends (*)	
	connection of a floating unit to a fixed platform through dynamic riser, subsea pipeline, and fixed riser.	major system such as export line from deepwater or shallow water unit to a receiving shallow water platform
	connection of a floating unit to a subsea unit through dynamic riser, subsea pipeline, and jumper (*)	these systems cover a wide range of applications for deepwater infield or interfield tie-ins
	connection of an hybrid riser system (such as a riser tower) to a floating unit through a riser, a bottom jumper, a pipeline, and a dynamic riser	the hybrid riser systems are generally of proprietary type
	connection of an hybrid riser system to a subsea unit through a riser, a bottom jumper, a pipeline, and a second jumper	the pipeline system does not cover the whole structure of the hybrid riser but only the dedicated conduit inside this structure
	upper connection of an hybrid riser system to a floating unit, through a subsurface jumper (generally of flexible type)	



Appendix 2 Guidelines for the use of the design data

Soil data

Soil data are needed to:

- determine the main concerns and issues along the intended route of the Pipeline System and properly address any needs of local route changes,
- determine the needs of survey works and/or soil preparation works before the installation of the Pipeline System,
- determine the interactions between the Pipeline System components and the soil, so as to derive the horizontal and vertical stabilisation requirements,
- determine the heat transfer conditions between the components, the soil and the surrounding water,
- perform specific analyses such as but not limited to : pipelaying, bottom-tow, anchorings, on-bottom stability, end expansions, freespan limitations, upheaval buckling,

The following data are of essence:

- type and mechanical properties of subsurface soil,
- soil horizontal and vertical friction coefficients or more refined models such as p-y curves,
- subsurface layer thicknesses,
- site bathymetry with reference contours,
- pipeline route profile, with expected or confirmed bottom roughness,
- landing conditions,
- soil stability (subsidence, mudslides, seismic, ...).

The corridor shall be determined, and otherwise instructed, shall be of 300 m to 1000 m wide. These data shall be reported along with the applicable chart datum they refer to; a unique chart datum system shall be specified, unless otherwise needed (i.e. for very long pipelines).

Oceanography

Oceanographical surveys made along the pipeline route shall be analysed. Interpolation and extrapolation from existing sites shall be approved.

When dynamic application are foreseen, detailed scatter diagram are required to enable fatigue analysis, but If these are unavailable, the following general reports may be used:

- oceanography reports,
- nautical charts and briefs,
- oceanographical reports on nearby or similar sites (Ocean Wave Statistics, etc.),
- satellite reports,
- local observation station or ship reports.

The determination of the seastates is required at typical return periods. These periods are generally taken amongst the following ones : 1 yr, 10 yrs, 50 yrs and 100 yrs.

Note: other return periods may be also specified by the reference documents or the project particular specifications. As an example, crucial pipelaying or riser upending phases may require the use of predictive seastate conditions at return periods below one year when these conditions are deemed critical during the intended installation period.

The following seastate data are needed for each one of the considered return periods:

- current elevation profiles in the eight main directions, at spring, mean, neap and equinox tides,
- significant and maximum wave period and height in the eight main directions
- amplitudes of spring, mean, neap and maximum equinox tides



- water rise/fall under wave and wind conditions
- ice hazards
- wave breaking regions
- current corridors
- water temperature, salinity, density, and chemical composition,
- marine fauna and flora which may affect the Pipeline System at various water depths,
- sea bottom visibility.

When there exist facilities in the vicinity of the Pipeline System, the seastate data are generally available but the uncertainties on these data may involve additional investigations to be performed in the course of the design phases.

Meteorology

The following shall also be determined from the same documents:

- Wind analysis according to direction, intensity, mean velocities, for each month of the year as a time percentage
- Annual and 100 year storm conditions with maximum wind velocities and duration (gusts)
- Air temperature, mean atmospheric pressure and major variations
- Mean visibility (fog regions, etc.)

Flow Contents

Flow data are needed to:

- specify the flow inlet and outlet acceptable range of pressure, temperature, fluid velocity values whenever any such ranges have not been already specified by the project requirements
- optimise the bore diameter of the Pipeline System components,
- optimise the internal corrosion / abrasion prevention measures,
- perform specific analyses such as but not limited to : end expansions, free span limitations, UHB/LB,

These analyses involve the assessment of the pressure and temperature profiles together with the type and velocity of the flow at any location along the Pipeline System and during its intended service life.

These profiles are:

- either already part of the design data,
- or to be determined in the course of the design studies.

If such profiles are not already part of the design data, they shall be determined on the basis of the following data:

- type and chemical composition of the fluid
- solid contents,
- type of flow envisaged, single or multiphase flow,
- characterisation of fluid within the expected range of pressures and temperatures along the Pipeline system and during its service life: specific mass, viscosity, compressibility, thermal conductivity, specific heat, etc.,

Miscellaneous

Data concerning the zones where pipeline system are to be located shall be gathered along with data on activities in the surrounding area. Data shall especially concern:

- Any special legislation on the environment of the pipeline system
- Location of platforms, pipelines, moorings or other existing works
- Dynamic response of each termination facility
- Location of wrecks or other substantial debris
- Sea traffic lanes, fishing areas