



Exploration & Production

GENERAL SPECIFICATION

PIPELINES - RISERS

GS PLR 107

**Design and construction of pipelines in
swamp and marsh areas**

00	10/03	First Issue
Rev.	Date	Notes



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1. Scope

This General Specification is applicable to the Pre-project design, the Basic design, and some critical aspects of the Construction phase, of offshore and onshore pipelines located in the marsh and swamp areas.

The word 'pipeline' covers the production flowlines between remote wellhead and satellites, the production trunklines, the export oil lines, the export gas lines, the condensate lines (stabilised or not), and the injection lines.

This General Specification shall be used in conjunction with the other Total General Specifications, and especially those listed in the **GS PLR 000**.

Neither the content of this General Specification, nor an omission in documents provided by the COMPANY can be used as a basis for release from the commitment to the proper performance and completion of the design.

Alternative design procedures in compliance with the requirements of this General Specification may be proposed; such alternatives shall however be substantiated either by the fact that they have been applied on other projects or by documented proof submitted to the COMPANY for approval prior to their application.

2. Reference documents

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

Standards

Reference	Title
ISO 13623	Petroleum and natural gas industries- Pipeline transportation systems

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
ASME B31.3	Process Piping
ASME VIII division 1	Rules for Construction of Pressure Vessel
BSI PD 5500	Specification for unfired fusion welded pressure vessels
DNV RP E305	On-bottom stability design of submarine pipelines

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS PLR 000	General Specification catalogue
GS PLR 001	Documentation requirements
GS PLR 002	Organisation of the design works
GS PLR 100	Submarine pipeline systems
GS PLR 403	Installation of onshore pipelines
GS PLR 404	Installation of steel pipeline by horizontal directional drilling
GS PLR 406	Packaging and transportation of line pipes
GS COR 220	Three layer polyethylene external coating for pipelines
GS COR 221	Three layer polypropylene external coating for pipelines

3. Definitions

In this General Specification and in its use, the following definitions shall be used:

- PRE-PROJECT** : The report containing all the studies specifying and sizing the Works based on their functions and known environmental conditions. In particular, the Pre-Project shall allow COMPANY to:
 - confirm the technical feasibility of the project.
 - set up a budget estimate for the project development.
 - have surveys and any additional measurements performed.
 - issue Project design Call for Tender.
- DESIGN**: All analysis, calculations, quality assurance and optimisation works performed for the **PRE-PROJECT** and **PROJECT**.

- **WORKS** : The onshore or offshore pipeline system, which can be also named "Pipeline System", and including :
 - the pipeline itself (including risers and expansion loops)
 - the right of way (ROW)
 - the supporting system if any and the anchoring system (if any)
 - the cathodic protection system and insulating joints (if any)
 - all appurtenances (valves, scrapper traps, SCADA, etc..)
 - the interface limits of the **WORKS** shall be specified in the **PROJECT SPECIFICATIONS**.
- **SMPL**: means Swamp and Marsh areas PipeLines, as covered by the present General Specification.

4. Codes, Rules, Calculation

4.1 Codes and Rules

Unless otherwise specified or required by this General Specification or the by the Project Specifications, the latest edition of the [ISO 13623](#) shall be used as the prime reference for the design of SMPLs.

For gas or production lines (when applicable) design factors to be used are those given by [ISO 13623](#) as per location classes and categorisation of fluids with the following exception: factor 0.83 is not allowed whatever the conveyed fluids or the considered locations.

4.2 Order and Precedence

All design, engineering, materials and construction shall generally conform to Total General Specifications, except where Local Statutory Codes and Regulations indicate otherwise.

The order of precedence of requirements shall be generally as follows unless otherwise directed in writing by COMPANY:

First : Local Statutory Codes and Regulations

Second : Total General Specifications, Particular Specifications

Third: International Codes and Standards.

When compliance with the above is considered to be impractical or uneconomical, alternative solutions to the COMPANY advantage shall be presented giving full details of the alternative solution proposed and its effects on the technical and commercial aspects of the Project.

4.3 Softwares and calculations

All calculation formulae used shall be explained and sufficiently detailed to allow the COMPANY to check the basis for design quality and validity of these calculations.

When computer programs are used, a description of the analytical methods, theories used for writing the programs and their references shall be submitted to the COMPANY for approval.

All computer programmes (or softwares) are to be validated before use.

Hand calculation are acceptable both for design purposes or verifications.

5. Definitions of types of locations

To avoid misunderstandings the following definitions/abbreviations shall be used:

5.1 Pipelines in Swamp or mashed areas

In this document, the abbreviation for pipeline(s) in swamp or marsh conditions shall be SMPLs (see definition in section 3).

5.2 Offshore

The location 'offshore' for SMPLs (see definition in section 3) is defined as areas located in open sea where the depth is greater than –13 m LAT.

5.3 Nearshore

When one end of the pipeline is located offshore at a depth less shallow than -13 m LAT, then this part of the pipeline shall be considered as nearshore pipeline.

The location 'nearshore' for pipelines is defined as areas located in open sea between the shore line and to the depth shallower or equal to –13 m LAT.

This area is the fringe between the shore and the offshore part. It may include part of a river mouth where influence of this river is fairly important.

Other local definition may apply.

5.4 River crossings

Distinction shall be done between the known navigable rivers, the non-navigable rivers, the channels and the creeks.

For practical construction reasons, amongst such crossings, distinction shall be also done between rivers having widths: less or equal to 36 m (3 x 12 m), then between 36m and 300 m, then wider.

Border between the river part and the nearshore part shall be given by a transverse theoretical line linking the two ends of the banks of the rivers.

5.4.1 Navigable rivers

Traffic on navigable rivers is insured by the commercial maritime traffic from the open sea to upstream part of the considered river, by transverse ferries, by others users (Navy, fishing activities, shuttles, etc...)

5.4.2 Non navigable rivers

The non-navigable rivers are rivers, which do not present either for practical reasons (depths) or due to their dispositions, any interest for commercial maritime traffic; however speeds boats, trucks boats, special construction barges may use in certain conditions these rivers.

Channels are streams transverse to the main rivers or to the non-navigable rivers having their origin in the swamp and originated by the tidal flux. Channels are still visible at low tides.

There are also rig access channels created by COMPANY or others, which need to be dredged/maintained for rig access.

These channels are normally considered as non-navigable except during drilling or well maintenance programmes where their maintenance shall be done (usually by COMPANY).

5.4.3 Creeks

The creeks are streams created by the water flows resulting from the tidal effects in swamps areas either along the pipeline route or transverse to the right of way.

Creeks are small channels not visible at low tides.

5.5 Swamps

Swamps are regularly or seasonably flooded areas. In these areas the water table can be found either at ground level for low lands or even at – 2 m in upper lands.

In these areas potential problems of vertical stability of the pipeline may be encountered (soil liquefaction) depending on the soil characteristics.

5.6 Onshore

Onshore locations are onshore areas where influence of the water on the pipeline stability in the trench is negligible.

5.7 Rig access channels

The rig access channels might be natural rivers deep enough (at least 3m) on dredged channels to allow rig to access to the wells.

The channels shall be identified at early stage of the project (during Basic to insure to identify in the call for tender) and special precautions are to be taken similar to the crossing of navigable rivers in case of natural channels, more stringent in case of dredged channel (additional trenching depth, additional protection live mattresses, etc.).

6. Essential data required for design

6.1 General

Essential data relative to the Works and the reference documents to be used shall be specified in a particular dossier named **Design Premises for the <Named> Pipeline(s)**.

This data shall be detailed to the extent required at that stage of design (Pre-Project or Project), i.e. which shall, in certain cases, be estimated.

Reference documents and data supplied in the above particular specification shall be carefully examined.

Check shall be made that the information available is adequate for design purposes.

When data absolutely needed for performance of the design is lacking, working hypotheses compatible with the works shall be proposed as a substitute.

Design data has been divided into two groups.

- the process data
- the description of the Works

Each pipeline within a project shall be considered as unique and shall be designed separately.

6.2 Process data

Determination of the following data or characteristics is essential to performance of the design:

- type of fluid (water, gas, crude, liquefied gas, production or refinery products etc.)
- type of flow envisaged : single phase, two or three phases, etc.
- the design value of the flow capacity
- chemical composition of the fluid including the CO₂ partial pressure.
- fluid density at various temperatures and pressures, possibly in the form of a graph
- the viscosity of the fluid at various temperatures and pressures, possibly in the form of a graph
- water/hydrocarbon dew point
- the maximum and minimum design temperatures
- the maximum and minimum operating temperatures
- the design pressure Pd
- the maximum operating pressures (MOP)
- the maximum and minimum flow rates (design and operating)
- permissible heat losses
- fluid specific heat
- fluid heat conductivity
- fluid compressibility
- temperature cycles
- pressure cycles
- maximum duration of shutdown (flow assurance)

It is important to note that one of the key factors in the design of SMPL may be the design temperature (corrosion, stability); this is normally given as being equal to:

$$T_{\text{max, operating}} + 15^{\circ}\text{C}$$

The design temperature shall be also used for the design of the aerial part of the line.

Other relevant information such as possible existence of erosion due to high velocity of fluids, presence of sands, possible elevation of temperature due to increasing expected water contents (at the end of the life of the wells), etc. shall not be forgotten to be given to the designer.

6.3 Description of the Works

The Design Premises dossier shall give a brief description of the Project, along with a diagram or layout drawing specifying the number and type of installations, covering in particular:

- the intended function of the works.
- the structures connected by the SMPL i.e. plants, loading terminal, processing unit etc. (for terminals, a provisional estimate of loading/unloading cycles shall be made).

- the proposed route of the SMPL with a clear identification of offshore part and onshore part, the swamp parts (i.e. part which are either regularly washed by water tides or part where the line when buried is going to be under the water table), the crossings with the existing other pipelines, the river crossings and other features having an impact on the design of the pipeline.
- SMPL origin and destination points and any other special points which shall be located on a geographical map.
- limits to the extent of the works.
- the proposed battery limits of the Works such as: isolation joints, pig-traps, flanges or clamps on a plants etc.
- the proposed pipeline diameter, grade and wall thickness, which shall have been provisionally specified by the process studies.
- the service life.
- the planned start-up date and the forecasted completion date which are specified at the beginning of Project Design (if known at the beginning of the Pre-Project).

6.4 Environmental characteristics

A description shall be made of the environment on the basis of available reference documents or documents approved by the COMPANY.

If these data are not readily available for the route of the future SMPL, design assumptions shall be based on those used on similar or nearby sites, on the state of the art and previous experience compatible with the works in question.

This description shall cover:

- Geographical data
- Topographical data
- Meteocean data
- Geophysical / Geological data
- Geotechnical data

6.4.1 Geographical data

Geographical data shall especially concern (non-limited list):

- general topography of the area
- location of types of forests (nipa-nipa, high trees, primary forest, mangroves, etc...) and agricultural areas (mainly paddy fields)
- location of protected areas such as natural parks
- location of rivers and channels, river bank features as creeks
- location of roads and tracks
- location of electrical high tension lines and networks, telephone lines, aerial antennas, etc...
- location of prohibited areas such as military zones (camps, etc...)
- location of petroleum facilities

- location of aqua-agriculture areas such fish ponds, fish traps, shrimp ponds...
- locations of special features such as religious buildings, etc...
- density of construction along the proposed route of the pipeline (village). To be noted that the density of population may also be considered as a design parameter.
- location of construction in progress

6.4.2 Topographical data

Topographical data shall especially concern (non-limited list):

- site topography with reference contours for the whole aerial part of the route
- pipeline route profiles with an accuracy of + or – 0.5 m

6.4.3 Meteocean data

Three areas to be considered:

- The offshore parts where the influence of adjacent/nearby river is attenuated by the distance to the shore and by the water depths
- The shallow water areas (including the shore approaches) where the characteristics of the waves and the currents are affected by both the shoaling effect and the adjacent/nearby river
- The swampy areas where the flooding of the grounds is given by both the water levels of the rivers and the tidal effects.

Meteocean data shall especially concern (non-limited list):

- wind analysis and for dedicated features (such as vertical or horizontal flares, vents or burn pipes, etc...) the direction, intensity, mean velocities, for each month of the year as a time percentage
- annual (operational) and 100 year (extreme) storm conditions with maximum wind velocities and durations (gusts)
- maxi and mini air temperature (day and night)
- maxi and mini soil temperature (day and night) at 1 m depth
- rain fall records
- sun radiation
- hygrometry
- maxi and mini and mean atmospheric pressure and major variations
- LAT, HAT, and MSL levels at river crossing and in nearshore/offshore areas
- current velocity and flow regime
- minimum temperature of the sea/clear water with 0.5° of accuracy
- Hs and associated period of the seasonal, annual, 10 years and 100 years return and their corresponding headings
- Sea/clear water current velocity with an 0.1m/s accuracy and at surface and at one metre above the sea/river bottom with corresponding direction (10 years and 100 years return)

Some of these data are not immediately necessary for the proper design of SMPL. But these data may be useful to evaluate unexpected situations such incidents or abnormal conditions.

6.4.4 Geological /geophysical data

Information of the properties of the seabed soils along the pipeline route is necessary for the pipeline design. The following soil parameters shall be provided. These parameters shall be derived from laboratory and in-situ data and/or from relevant experience.

Geological / Geophysical data shall especially address (non limited list):

- bathymetry
- morphology
- seabed features including travelling sand waves
- shallow geological profiles
- seismic fault crossings
- soil electrical resistivity for cathodic protection

6.4.5 Geotechnical data: soils in place

For **soils in place**, the required parameters are as follows:

Soil	Identification parameters	Mechanical and consolidation parameters
Clay	Grain size distribution Atterberg limits Water content Total unit weight Specific gravity Organic matter content	Undrained shear strength elastic modulus Remoulded shear strength sensitivity Undrained friction angle Consolidation characteristics Permeability Spring stiffness
Sand or silt	Grain size distribution Relative density Max / Min density Total unit weight Specific gravity Organic matter content	Drained friction angle Elastic modulus Undrained friction angle Permeability Spring stiffness
Rocks	Total unit Weight	Compression strength Young modulus Spring stiffness

Other parameters are (all types of soil):

Corrosion	pH of soil Sulphate content Chloride content Sulphide content Electrical resistivity
Thermal consideration	Thermal conductivity Salinity

Soil pipeline interaction	Longitudinal pipe-soil friction coefficient Transversal pipe-soil friction coefficient
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6.4.6 Geotechnical data: backfill material

For **backfill material**, the required parameters to define the backfill potential and also the scour potential are as follows:

- Grain size
- Unit weight
- Specific gravity
- Friction angle.

6.5 Arctic and seasonal frost zones

In addition, the following shall be assessed:

- Seawater areas together with ground areas, which are subjected to temporary or permanent icing, shall be clearly identified.
- Period(s) of icing shall be defined in yearly, centenary and thousand year conditions.
- Extreme temperatures (mini and maxi).
- Maxi and mini thickness of ice.
- Thickness of drifting ices.
- Period of drifting.

7. Pre-project analysis

The main analyses to be performed are both the technical and economic studies for the projected works.

These studies should result in a description of all essential characteristics of the works with an estimate of the overall budget required.

Pre-Project shall be done normally by COMPANY.

7.1 Pre-Project File Contents

The complete Pre-Project File (which shall end in the Statements Of Requirements) shall contain the following sections in a single, ordered, and referenced report:

7.1.1 Introduction

The introduction shall consist into a brief description of the works to be performed and of the analysis with a summary of the options selected for the performance of the works.

7.1.2 Design Assumptions and Data

This section shall contain all data and information used in the studies and the reference of the original documents.

In addition the battery limits of the pipeline system together with the Codes limits shall be clearly indicated.

7.1.3 Technical Studies

The technical studies report shall be broken down into several sections, each corresponding to a study on one of the Project's characteristics.

Each section shall contain a brief review of the data, the assumptions and methods used, and all analytical computations.

The results of these studies shall be given in tabular or graph form according to requirements and shall include, as a minimum:

- the brief description of the proposed route of the pipeline, the basic description of the ROW and the trenching/burying requirements
- the pre-sizing of steel pipes for the pipelines and any other part of the works, particularly :
 - outside pipe diameter
 - wall thickness
 - steel grade
- the pre-sizing of stabilising devices, i.e. generally the concrete coating thickness used for pipelines stabilisation (swamps, nearshore and offshore pipelines)
- special recommendations concerning protection against corrosion :
 - types of internal and external coatings for pipeline- and risers
 - cathodic protection
 - steel corrosion allowance
 - inhibitors
 - steel chemical analysis
 - corrosion monitoring
- the pre-specification of special items such as :
 - valves (on-line)
 - tees
 - expansion parts
 - connections
 - crossings with other pipelines, cables, roads, rivers, etc.
 - vents
 - communication system
 - SCADA
 - pigging requirements
 - pipeline overpressure protection system
 - etc.

NOTE: Metering is not considered as relevant to this present General Specification but rather relevant to the upstream (or down stream) process parts of the pipeline system. Metering shall be dealt by COMPANY's instrumentation discipline.

7.1.4 Preliminary Drawings and Documents

The drawings and documents required for the basic design of the works shall be included in the Pre-Project Study.

To be included are:

- the preliminary pipeline route layout and route profiles together with the indication of the estimated kilometre points (KP).
- the field layouts
- sketches showing the special points such as :
 - description of crossings (pipelines, cables, roads, railways, rivers etc).
 - description of special methods, such as aerial supporting, trenching...
- technical specifications covering connecting pipes and valves.

7.2 Methodology for Pre-Project study

This section describes the methods to be used for the pre-project studies.

7.2.1 General

For Pre-Project phase, the procedure consists in studying the Works design.

An overview of study development shall be maintained at all times, so as to ensure that the Pre-Project studies do correspond to the Project's design rules.

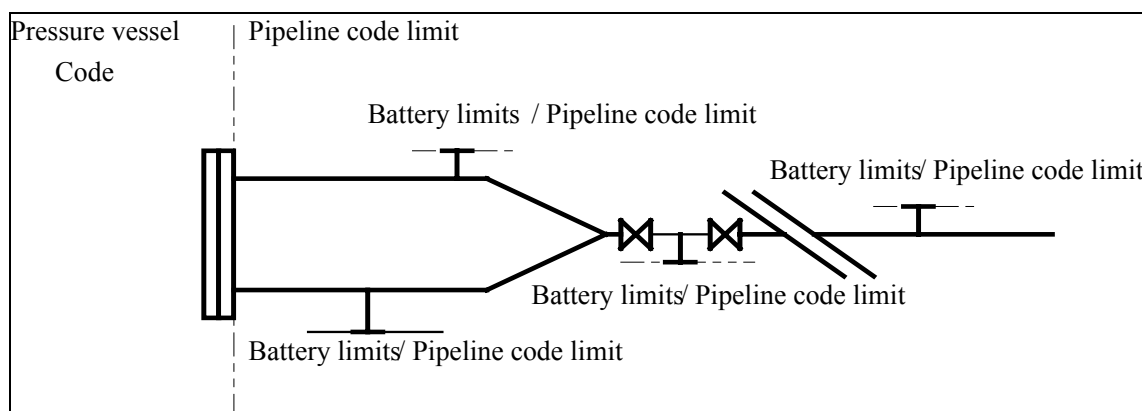
Each parameter of the Pre-Project studies shall be optimised from the basic data; optimisation of a parameter may induce changes for other parameters.

7.2.2 Battery/code limits

Pipeline system is defined as per [ISO 13623](#).

All the appurtenances connected to the pipeline in the plants area (arrival and departure including intermediate areas) shall used flanged type connections and shall be relevant to other specific codes such as [ASME B31.3](#) or other.

Within the pipeline system, the code limits shall be at flanges level and as hereafter:





However other pipeline features such as valve pits, impressed current stations, SCADA, in-line vents, Right-of-Way, slug catcher, etc., relevant to other codes or standards are still part of the Pipeline System.

As a basic case, aerial piping at sectionalising valves and on onshore manifolds (located on ROW) shall be designed as per [ASME B31.3](#).

7.2.3 Hydraulic Analysis

The hydraulic analysis results shall be given by COMPANY process people.

If during the Pre-Project study it is demonstrated that a major hydraulic parameter needs to be changed (e.g. pipe inside diameter), the COMPANY pre-project manager shall be notified immediately and a new hydraulic analysis with the new parameter(s) shall be re-run.

7.2.4 Pre-Project Dimensioning Steel Tubes

Tubes shall be pre-sized according to an internal design pressure and temperature. Considerations shall also be given to ambient and mechanical influences and various loads.

Design for any SMPL shall be done as per [ISO 13623](#)

It is to be noted that the most significant factor contributing to the failure of a gas pipeline being damage to the line caused by the activities of people along the route of the line, it shall therefore be imperative to define the different location classes all along the route of line.

The location class with respect to the local Regulations (if any) shall not be forgotten.

Selection of steel grade shall be based on technical consideration (wall thickness, corrosion, weldability, etc.) and on economic considerations.

The souring severity of the effluents shall be definitively cleared by COMPANY's corrosion and material discipline.

The adopted steel grade shall be submitted to the technical Pre-Project Manager as soon as possible upon commencement of analysis.

7.2.5 Pre-Project Dimensioning for Sustained, Occasional Loads and Thermal Expansion

For onshore liquids pipelines, a basic stress analysis at pre-project phase for Sustained, Occasional Loads and Thermal Expansion shall be performed but analysis of the singular points for stress evaluation as river crossings, aerial parts etc. shall only be made for budget purposes in order to evaluate the magnitude of the costs impacts.

Stabilisation using the self weight of the steel pipes or concrete coating shall be adopted as the basic approach for swamps, offshore and river crossings; alternative means that meet the project's requirements shall be provided as soon as this solution is found unsuitable.

As a general rule, all pipes shall be designed for stability (static and dynamic) in the given soil conditions.

For offshore pipelines, where dynamic effects of waves and sea/river current actions are expected, then the DNV 81 safety factor shall be strictly adhered to. In addition, there is no requirement for burying (unless otherwise advised by the Project or by the Local Regulations).

At pre-project stage, stability of offshore pipeline part shall be done as per [DNV RP E305](#) requirement in combination with DNV 76 drag and lift coefficient ($C_d=0.7$ and $C_l=1.2$)

Depending on the soil characteristics and especially for the shore approaches, river crossings and swamps, the risk of soil liquefaction (and its consequences) due to some burying techniques (water jetting) shall be evaluated.

As a basic rule it is asked to get a submerged density of the pipelines up to 20" OD equal to 1.5. For larger pipeline, when upheaval buckling is not anticipated, handling problem may requires to decrease this density down to the minimum value of 1.2.

Depending on soil characteristics, risk of sinking shall be evaluated.

7.2.6 Pre-Project Requirements against Corrosion and Erosion

7.2.6.1 Internal Corrosion-Erosion

COMPANY corrosion discipline shall be required:

- to determine the critical velocity for inhibitor removal to avoid internal corrosion-erosion
- to estimate the corrosion rate and the subsequent corrosion allowance.

The water condensation inside of the pipe can cause top of line corrosion (TOLC). TOLC can take place if:

- the flow regime is stratified or stratified-wavy (large pipes with low liquid flow rates) and
- the temperature difference between external environment and internal gas is high.

The water condensation rate shall be calculated taking into account the nature/thickness of the pipe coating, pipe thickness and other parameters which are necessary for heat transfer calculations.

7.2.6.2 Corrosion Allowances, Treatment and monitoring

In order to maintain the serviceability of the production pipelines, sufficient corrosion allowance shall be provided. The corrosion allowance shall be estimated by COMPANY corrosion discipline (evaluation of the corrosion rate is based on the fluid corrosivity).

The inhibitor efficiency shall be considered as 100 % but the inhibitor availability shall be:

- 90% for the wellhead flowlines
- 95% for the trunklines
- 95% for export oil export lines
- 90% for wet gas export lines

A water soluble corrosion inhibitor may be required to be continuously injected at a rate that shall be specified by COMPANY's corrosion discipline.

If the risk of TOLC exists, COMPANY's corrosion discipline shall define the required methodology to mitigate this risk.

Pig launchers and pig receivers shall be available on all trunklines where risk of TOLC is highlighted.

In case TOLC risk exists, if proven practical, submerged expansion loop shall also be protected.

NOTE: TOLC in the expansion loop can be controlled by the following options:

- the expansion loop can be heat insulated in compliance with § 7.2.7

- the expansion loop can be considered as consumable with a service life about 10 years; thick expansion loop - with typical corrosion allowance of 10 mm - with flanged connections (to the pipe and to the riser) can be used.
- stainless steel or internally CRA clad expansion loop (or longer loop length, if required by COMPANY's corrosion discipline) with flange connections can be used; precautions shall be taken to prevent galvanic corrosion between carbon steel pipe/riser and stainless steel/clad expansion loop.
- the last two options shall be considered as alternatives to a thermally insulated carbon steel linepipe with corrosion allowance and regular batch treatments.

7.2.6.3 External Anti Corrosion Protection

The requirements for the external pipe coatings are summarised below:

- anti-corrosion coating shall be three layer PP suitable for maximum operating temperatures 60°C and above.
- field joint coating shall be either two layers PP applied by flame spray technique or PP Coex-tape applied on FBE primer
- hot enamel coating, polyethylene coating, heat shrinkable sleeves, cold applied tapes are not acceptable for the SMPLs even with concrete coating .
- anticorrosion coating shall be three layers polyethylene for maximum operating temperatures up to 60°C.
- heat shrinkable sleeves can be used for field joint coating
- cold applied tapes shall not be used for field joint coating;

The cathodic protection shall be either impressed current system or sacrificial anodes. If the latter is selected, anodes shall be installed on sledges and connected to the pipes by cables at regular intervals. Anode shall not be installed on the pipes (no bracelet anode shall be used). Number of anode locations shall be optimised.

7.2.7 Thermal insulation

As required and as per results of the process studies requirements for thermal insulation shall be defined.

Flow simulations in different configurations shall give the thermal profiles of the line.

The required U factor shall be determined.

Thermal insulation methods shall then be proposed. Tests campaigns if necessary shall be defined.

Polyurethane or EPDM shall be used for heat insulation of doglegs and of subsea expansion spools.

Polyurethane shall be applied above the three layer PP or PE anti-corrosion coating and the prequalification process shall be obtained from or approved by COMPANY's corrosion discipline.

7.2.7.1 Submerged exposed areas

The comprehensive study shall be carried out to investigate the possibility of TOLC (especially on field joint areas) on the submerged exposed parts.

If such locations can be identified during project, they shall be coated by a heat insulation coating as defined above.

7.2.7.2 Dog legs and Risers

Doglegs shall be free to absorb thermal expansion of the pipeline and then shall not be buried or anchored by materials.

If this status can not be insured during the life of the pipeline, either soil sampling shall demonstrate that the backfilling material does not prevent the movement of the line or alternatively calculation shall demonstrate that the adjacent riser, the expansion spool and the pipeline can safely sustain the residual stresses developed during shut down or cooling phases.

These expansion loops and adjacent submerged or washed risers shall be coated by an anti-corrosion coating and heat insulation coating to prevent TOLC when required.

These parts are not concrete coated.

7.2.8 Pipeline laying

For the Pre-Project, installation analysis shall confirm technical feasibility (e.g. horizontal drilling for navigable river crossings) and define procedures so as to enable cost estimation.

Installation methods for the near shore parts and the shore approaches shall be confirmed.

In all cases, when back-covering of the pipeline is required for stability or thermal insulation reasons, natural back-filling for trenched pipeline is not considered as acceptable and reliable method.

In order to meet the Overall Project Schedule, different alternatives such as use of several installation construction spreads may be contemplated.

The recommended laying methods for the various basis cases are:

7.2.8.1 Shore approaches

For shore approaches a winch shall be positioned onshore and the line shall be pulled from the barge to the shore inside the trench.

Covering of the pipeline by adequate materials shall be done.

Alternatively the line is constructed onshore and the string is pulled to the barge, recovered on the stinger or laying ramp for continuation of laying towards deeper areas.

7.2.8.2 Near shore

The laying for the near shore shall be performed from a laying barge with tensioning system as necessary.

Pre-trench operation and post trenching operation shall be done.

Covering of the pipeline by adequate material shall be done.

As base case, near shore pipeline crossings shall be done in such a way that the existing line shall never whatsoever support the new line weight (0.30 m gap).

7.2.8.3 Swamp

Push-pull methods shall be performed inside a pre-trench followed by a covering operation.

Swamp banks shall not be touched by construction operations.

For pipeline crossings the new line shall cross underneath the existing one.

7.2.8.4 Offshore

Traditional laying operation from a laying barge shall be done.

As base case, near shore pipeline crossings shall be done in such a way that the existing line shall never whatsoever support the new line weight (0.50 m gap).

7.2.8.5 River crossings

Two main types of river crossings are to be contemplated:

- Navigable rivers
- Non navigable rivers including rig access channels

7.2.8.5.1 For navigable river (up to 24" and 2000 m overall length),

The preferable crossing arrangement to avoid potential problems linked with marine activities and seabed erosion is the horizontal directional drilling; however this method is limited in terms of diameter of the line and length of crossing.

Local requirements such as for spare line may apply.

7.2.8.5.2 For crossing others than those performed by horizontal drilling,

The following methods or combination shall be used:

width of crossing	method
up to 36 m	onshore/surface construction of the line and installation of the string in the trench.
above 36 m and up to 300 m	onshore construction of the line and pulling of the string in the trench.
above 300 m	depending of the current and of the total length either onshore construction and pulling or conventional laying from a laying barge shall be done.

7.2.8.6 Onshore

Conventional laying method shall be used.

Logistics shall be prepared to accommodate heavy rains or frozen grounds. For pipeline crossings the new line shall cross underneath the existing one.

7.2.9 Burying depths

Unless requested for other technical reasons (e.g. ice pits) or by local regulations, the [ISO 13623](#) requested burying depths are amended as follows (from top of pipe):

Shore approaches	1.5 m below the mud line
Near shore	1.5 m below the mud line
Swamp	1.5 m below the mud line

Onshore	1.0 m below ground levels
River crossing	2.5 m for navigable river and natural rig access channel
Dredged rig access channels	to be advised

When geotechnical data are available in some areas along the pipeline, if better soil can be reached, possibility to trench deeper is given.

7.2.10 Pre-commissioning at Pre-Project Phase

7.2.10.1 Pipeline Integrity

At the end of the construction and prior to the hydrotest, a geometrical intelligent construction pig (type GEOPIG from BJ, ROSEN, TD Williamson, or equivalent approved by COMPANY) shall be run to record all along the pipeline the internal geometry (IDs @ XYZ) of the pipeline. The detected defective parts (dents, buckle) which do not comply with the COMPANY acceptance criteria shall be repaired.

7.2.10.2 Pressure Tests

7.2.10.2.1 Tests

Tests for pre-commissioning shall be conducted as per [ISO 13623](#) amended by the following COMPANY requirements:

- at the end of construction a pig trap to pig trap pressure test combining strength test and leak test is to be conducted.
- the duration of this strength test is 24 hours.
- medium used for the test shall be treated water (seawater or fresh water) as specified by COMPANY's corrosion discipline
- the ratio $\frac{t_{\min} + \text{corrosion allowance}}{t_{\min}}$ shall apply only if the corrosion allowance is greater than 5 mm.

7.2.10.2.2 Pressure tests

In the following, the Design Pressure shall be used in place of the MAOP (as per code).

For onshore gas (D and E products) pipeline, the pressure tests for location class 1 and 2 is 1.25 x Design Pressure and 1.4 x Design Pressure for class 4 and 5 (separate tests)

For liquid pipelines, the test pressure shall be 1.25 x Design pressure.

For pipeline with parts both onshore and offshore, the final test pressure for the test from pig trap to pig trap shall be 1.25 x [Design pressure less the external hydrostatic pressure].

For offshore pipeline risers and doglegs, as per [ISO 13623](#), the final test pressure for the test from pig trap to pig trap shall be 1.25 x [Design pressure less the external hydrostatic pressure].

Disposal of the used test water shall be done safely with due regard to the environment.

7.2.11 Logistic aspect

For the Pre-Project an evaluation of the logistic problems shall be done highlighting the Local Regulations requests regarding the importation problems, the remote locations of the concerned areas, the mob-demob costs, the local contents.

In addition, the following typical points shall be assessed:

- equipment delivery points / formalities / custom clearances / regulations
- marine aspect
- transport facilities (for personnel and equipment)
- construction camps
- maintenance workshops
- water
- food & accommodation
- local suppliers, performances and capabilities
- telecommunications (work sites, camps, head offices, etc.)
- explosives
- heavy lifting equipment
- road/air/rail/sea transport of material/Equipment
- storage areas
- civil works equipment
- medical assistance/evacuation
- fuel
- access roads
- manpower, performances and capabilities
- reporting/inventory/procedures
- etc.

7.3 Requirements for Pipeline Route selection

7.3.1 Method

The route selection shall be an iterative and joint exercise between:

- on COMPANY's side: the Pre-Project team and the Technology Division,
- on Subsidiary's side: the Construction, the Field Operations, and the Drilling when constraints due to rig access channels shall be sorted out as early as possible in the course of the PRe-Project.

At this step of the project, the pipe line route selection is a desk study based on existing area maps.

This desk study shall be performed by a pipeline engineer assisted by a topographical/survey engineer.

The desk study shall identify the different location parts of the pipeline as indicated by the maps: offshore parts, near-shore parts, swamps parts, flooded parts, onshore parts and water courses crossings.

Existing ditches, roads, tracks and other constructions shall be noted.

Areas with possible crossing of creeks/streams shall be identified.

As soon as the preliminary route is frozen, instruction for a photographic aerial survey is to be done to identify existing constructions not on the maps (such as fishponds, paddy, shrimps ponds, etc.).

7.3.2 Other Considerations for SMPLs route

Very shallow depths in open sea areas are very constraining for pipeline laying and have a critical impact on the access of the barge itself and on its progression (access channel and anchor handling tugs) and this shall be accounted in the route selection.

In addition:

- in order **to avoid** an ideal upheaval buckling configuration, the shore approach **shall not** involve a 90° turn with subsequent onshore anchoring of the line; as a consequence, local vertical expansion loops shall be engineered
- the following list of basic requirements for water courses crossings of SMPLs is not restrictive and is not a release from the commitment to analyse any other particular point relevant to pipeline route such as:
 - a change in horizontal direction at a crossing, or within the crossing, is not allowed without proper engineering study
 - change of direction shall be done on the air exposed bank at least 100 m (preferably after having reached the HAT water limit) or after the river bank edge
 - change of direction shall be done so that there is no aerial or submerged part of the pipeline crossing which can be subject to detrimental axial forces resulting from the onshore pipeline expansion.

7.3.3 List of basic requirements for the route

The following list of basic requirements to avoid bad routing of SMPLs is not restrictive and is not a release from the commitment to analyse any other particular point relevant to pipeline route:

- the pipeline shall follow at first the most direct line between departure and arrival.
- offshore pipeline route shall take into account the bathymetry contour to avoid up and down profile but also to ensure lateral stability
- the offshore pipelines shall land perpendicular to the shore
- initial KP of the proposed new line shall start at flow departure
- the pipeline shall cross as perpendicular as possible rivers and other water courses
- the onshore pipeline shall not follow the contour of a slope (stability reason)
- the minimum angle of crossing of a near shore or offshore pipeline with an other pipeline should not be less than 30°.
- the pipeline shall not be laid in the closed vicinity of the extrados of a river turn (risk of erosion of the banks) and a minimum distance of 100 metres shall be respected.
- the installation of subsea pipeline following the bed of non navigable river although easier to install is not normally allowed as there are concerns on the pipeline stability problems due to the possible erosion of the cover above the pipeline; however derogation to this rule may be sought.
- laying of pipeline along/inside navigable rivers is prohibited.
- along a standard onshore ROW, the minimum distance between each onshore (gas or liquids) line shall be as **GS PLR 403**, unless otherwise specified by the Local Regulations.

- in river crossing where pipelines are laid parallel, a minimum distance of 15 m between edge sides of these pipelines is to be considered as basic case.
- all the expected features (villages, religious buildings, isolated houses, petroleum facilities, roads, tracks, etc.) shall be clearly noted for site survey counterchecking.
- swampy or potentially submerged anticipated areas shall be noted for site survey confirmation
- tentative of location class identification shall be crosschecked by on site survey.
- for near offshore pipelines, crossing of sandbanks is allowed.
- in area close to wellhead platforms pipelines shall be routed on the opposite side from the drilling rig spread (including supply boats) restricted area.

7.3.4 Final Adoption of Pipeline Route

At the end of the Pre-Project Phase, the adoption of the final pipeline routes at the Pre-Project level shall be done according to the following criteria:

- impacts on local populations (location classes for gas pipeline) and future anticipated population density
- optimisation of pipeline length
- optimisation of installation costs
- minimisation of failure risks during installation (slope too steep, horizontal drilling lengths, best route profile) or during operation (ROW maintenance)
- pipeline minimum curve radius
- provision for future expansion of the Project
- environment impact

7.4 River bank arrangements for typical water courses crossings

For the different crossings here below are given the basic instructions regarding the general arrangements.

7.4.1 Navigable rivers and natural rig access channels

width of watercourse	constraints and methods
up to 36 m	Too narrow to accept navigation of large vessels. Hence for rig access, the pipeline shall be installed below the mud line or natural river bed, at depth of 4 m - typically - measured above the top of the pipeline, to be checked on a case by case basis. Any risers shall be protected by piles on both sides. Mini riser platforms can be installed in special encroachment in the riverbank and on doing this it shall be checked that the flow regime of the river does not enlarge/damage the encroachment.
above 36 m and up to 300 m	By horizontal drilling, as base case, and whatever the

	pipeline diameter.
above 300 m and up to 2,000 m	By horizontal drilling, as base case, and whatever the pipeline diameter.
above 2,000 m	Conventional lying with lay barge and proper pipeline burying (- 2 m), as far as practicable, otherwise: Conventional mini riser platforms inside the river, close to the riverbank (to not damage the riverbanks), with proper riser fender/piles against marine traffic.

7.4.2 Non navigable rivers and temporary rig access channels

width of watercourse	constraints and methods
up to 36 m	Onshore/surface construction of the line and installation of the string in the trench. Final installation of riser connected to the line shall be done by the laying barge itself or by a tie-in barge equipped with lifting crane.
above 36 m	Conventional crossings (pre trench or post trench depending on soils crossing characteristics) with riser platform outside the river bank or shore approach not to damage the river banks, with proper riser fender/piles against accidental marine traffic (if any), except in very particular flat conditions (where use of riser is found inappropriate). Final installation of riser connected to the line shall be done by the laying barge itself or by a tie-in barge equipped with lifting crane.

7.4.3 Creeks

Pre-trenching at a depth where the future scouring due to the water flow. No risers but hot formed bends only (cold bends are allowed if not exceeding bending radii allowed by the [ISO 13623](#)) are necessary.

7.5 Sectionalising valves

Necessity of sectionalising valves shall proceed from a risk analysis. In addition, the following requirements shall apply.

7.5.1 Gas pipelines

For onshore gas pipelines (categories C, D and E as per [ISO 13623](#)), the COMPANY general requirements regarding the spacing of the valves shall be strictly adhere to:

class	1	2	3	4
spacing of valves	30 km	23 km	15 km	7 km



For OD pipeline greater than 24", closing device assistance shall be installed.

As requested by a risk analysis, remote operations of these valves shall be considered.

A dedicated study shall be conducted at pre-project stage (or alternatively during the basic) to check requirements in terms of production and start-up flexibility. Additional valves, crossovers or dedicated manifolding arrangements may be then required.

7.5.2 Liquids pipelines (other than water pipelines)

On riverbank of navigable river, the valve shall be located in an easy of access area, at a distance from the riverbank that shall be comprised between 5 m and 25 m, and a piggable sectionalising valve shall be installed in the upstream part of the pipeline.

On the downstream river bank, the valve shall be located at a distance not greater than 20 m from the river bank, and a piggable non-return valve shall be considered as base case to prevent back flow in the river.

7.5.3 Beach Valves

To avoid possible back flow from the upstream stream part in case of offshore damage of pipeline in the shallow offshore part, beach valve may be contemplated.

7.6 Environmental Baseline Survey

Once the preliminary routes are established, an environmental baseline survey shall be carried out as soon as possible to enable proper Basic Engineering.

Three zones shall be contemplated:

Zone A: Zone of most likely disturbance (30 metres wide) based on the construction working width

Zone B: Zone of possible disturbance around the published route, subject to any minor route modifications from this before construction commences (400 m wide)

Zone C: Overall environmental corridor within which pipelaying activities may have some, albeit limited, effects (1000 m wide as above).

This work shall aim to establish a broad overview of the proposed route establish areas of sensitivity and allow for recommendations to be made for further study work as necessary to ensure minimal impact by the Project and to recommend mitigation measures where required.

Other local environmental sensitive areas as listed in the route selection shall be highlighted and taken into account.

7.7 Survey, positioning and charting

For survey, positioning and charting, it is compulsory to obtain the methods and specifications relevant for swamp and marsh areas given from the COMPANY's Survey discipline.

It shall be noted that there are two main types of survey to be completed for the design part:

- a pre-survey - which can be performed by helicopter or by car - along the planned route as per the desk map study, shall aim at obtaining the pertinent data in order to assess the overall project and to confirm the initial choice

- the detailed route survey, which shall, in particular, aim at checking the accuracy and the pertinence of existing as-built documents of previous projects, and aim at gathering the environmental data.

Main results of all the various surveys shall be reported within the alignment sheets, and inclusive of all the required technical elements.

The technical aspects of this General Specification shall include, at minimum:

- route drawings (preferably the alignment sheets) and the relevant maps
- survey scope
- recommendations on the methods and types of equipment to be used
- the form in which the survey results is to be submitted.

7.7.1 Access to Site Location

Access to Site Locations may be found difficult for many reasons. Therefore assistance from the Local Authorities may be required to guarantee the free and safe access of the project workers to the different areas.

Contacts with the Local Authorities and negotiations (if any) with the populations shall be done by a dedicated team.

On a practical way, physical access to the site locations may be found impossible within the existing local road networks. Access tracks, tracks or ways may be constructed especially by the Project for the construction phase.

Some of these access ways may have to be maintained all along the life of the pipelines to allow future interventions (inspection, maintenance or repair).

Some parts of the routes or alternative routes need to be properly surveyed prior to any constructions for access.

Photographic aerial surveys and mapping works shall have to be done consequently.

To be noted that, for environmental policy reason, it is recommended to perform an aerial photo pre-survey. This dossier shall be kept in the Project Dossier.

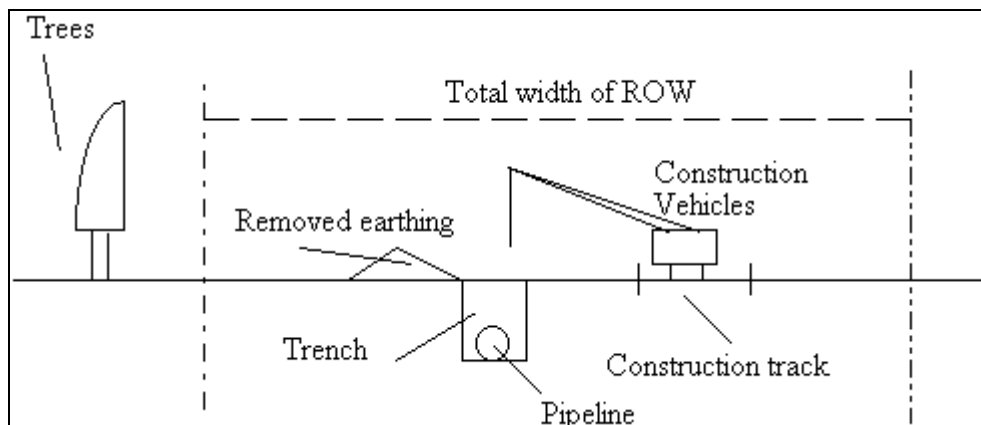
7.7.2 Land properties and new Right of Way

The basic case is to use existing ROW. In the case where the ROW are constricted due to the presence of other pipelines, it shall then be necessary either to try to use parallel adjacent lands of the existing ROW or to create new ROW.

In this last case, inventory of the properties to be crossed and to be purchased/rented/used for the Works is to be done with a sufficient accuracy to allow a reliable cost estimate.

Possible difficulties for expropriation shall be anticipated, in close cooperation with the Local Authorities.

A typical arrangement of a ROW during the construction phase shall be as follows:



As a base case the following total width of right of way is to be considered:

- for a 8 " a ROW width is normally 12 m
- for a 20" 15 m
- for a 32" 16 m

The construction track shall be maintained during the whole life duration of the Pipeline System for inspection/maintenance purposes.

In location class 3, it is requested to fence the side of the ROW and close the road access of the ROW by gates.

Note: future next phases of a field development shall be anticipated in the pipeline positioning within the ROW.

7.7.3 Alignment sheet specifications

A set of single overview of the whole route shall be produced on the most suitable scale, which shall serve as a key plan for all the alignment sheets.

All alignment sheets shall be sequentially numbered.

Each alignment sheets shall have a legend box on the right hand side. The contents of the legend box shall include, but not be limited to the following, and shall be displayed in the order as given:

- | | |
|---|---|
| • Title of the Project | • Symbols as used on the charts/profiles |
| • Geodetic datum | • Projection |
| • Spheroid | • Chart datum (CD) / MSL |
| • Chart name | • Chart / profile (vertical and horizontal) |
| • Contour interval | • Survey Contractor's name |
| • Survey vessel name (for nearshore and river crossing surveys) | • Date of survey |
| • A miniature chart overview with the bordering charts shown | • Kilometric scale, subdivided into tenths |
| • Issue number | |

A1 size shall be used and the utilised length is 700 mm for each sheet.

The units shall be the International Unit System.

The pipeline alignment sheets shall be plotted at the vertical and horizontal scales defined by COMPANY in the Particular Specifications and shall consist of four (4) main horizontal strips as follows:

7.7.4 First strip : General location and topographical chart

- Site topography with reference contours for the whole aerial part of the route
- The theoretical pipeline route (centreline) with fix numbers, Turning Points (TP), Kilometre Points (KP), and all necessary information
- Location of types of forests (nipa-nipa, high trees, primary forest, mangroves, etc...) and agricultural areas (mainly paddy fields)
- Location of protected areas such as natural parks
- Location of rivers and channels, river bank features as creeks
- Location of roads and tracks
- Location of aerial or buried electrical high-tension lines and networks, telephone lines, aerial antennas, etc....
- Location of prohibited areas such as military zones (camps, etc....)
- Location of petroleum facilities
- Location of aqua-agriculture areas such fish ponds, fish traps, shrimp ponds...
- Location of special features such as religious buildings, etc....
- Density of construction along the proposed route of the pipeline (village)
- Location of construction in progress
- Near shore and river crossing
- The corrected soundings over the whole surveyed corridor
- Bathymetric contours with a 0.1 m internal contouring at the horizontal and vertical scales defined by COMPANY in the particular specifications
- An annotation for all slopes beyond ten per cent. The direction of slope shall be clearly indicated. This information shall be made available to enable route development, if necessary
- Geology and seabed features (e.g. sand waves, pipes and cables in/out of service and planned, objects or any obstruction if any, trawling tracks, etc....)

In addition, the following information shall be plotted:

- Geotechnical borehole location
- CPT locations
- Current meter, tide gauge and wave recorders locations
- Resistivity measurements locations



7.7.5 Second strip : route profile

The second strip shall show the vertical profile along centreline of the route. In addition to the altimetry and the bathymetry the following shall be displayed:

- The nature of the soils with a shallow geological description and main geotechnical results
- The slopes, with indication of the slope values in percentage
- Turning Points (TP), Kilometre Points (KP), and all necessary information

7.7.6 Third strip : Survey results

Main survey results shall be presented approximately below the measurement location situated on the chart and the profile. These main results shall include:

- Meteocean data (tides, bottom and surface currents, Hs/Hmax)
- Geotechnical data (main parameter values or curves and lithological description)
- Soil resistivity values

7.7.7 Fourth strip : engineering data

This strip shall be kept empty for pipeline design purpose.

7.8 Special COMPANY requirements

Due to the specificity of the swamp and marsh areas, the following special requirements are made by the COMPANY.

7.8.1 Material and Equipment

For SMPLs, grade of steel is normally limited to X65; however on a case by case basis it may be possible to use higher grade depending on the diameter, the thickness, the effluent quality and the capability of local manufacturers.

Special care shall be taken to the ability of the pipeline manufacturers to get the required thickness.

ERW (HFI) pipes shall normally be discarded for sour applications and gas applications until further notice from COMPANY's Pipeline & Risers discipline.

Flanges for subsea tie-ins at normally unmanned platforms are acceptable for pipelines up to 24" in OD.

For greater diameters, subsea tie-ins are to be performed by hyperbaric welds.

For depths greater than 100 meters, the best method shall result from a dedicated study.

All the hydrocarbon pipelines greater or equal to 10" in OD shall be piggable and inspectable by intelligent pig devices.

Special attention shall be paid for flowlines (6" and 8") which may require being internally inspected (decision by COMPANY's Corrosion discipline).

As base case, internal diameter shall be constant from pig trap to pig trap.

Design of pipeline network shall consider the pigging operations when selecting the diameter of the pipelines.

Permanent pig traps facilities (suitable for intelligent pigging or batching) shall be provided for inspecting the trunklines.

Surface piping shall enable also batch corrosion inhibition treatment without shutdown of pipeline.

Launching and receiving facilities shall have the handling/lifting adequate facilities.

7.8.2 External pipe coatings

For hot flowlines and trunklines (maximum operating temperature 60°C and above) the use of coaltar enamel or polyethylene is not acceptable.

Three-layer polypropylene (PP) coating shall be used for the protection of these lines against external corrosion in compliance with the **GS COR 221**.

The field joint coating shall be either:

- two layers polypropylene coating (FBE + PP) applied by flame spray technique
- PP coex-tape applied above the FBE primer

Other field joint coating systems like heat shrinkable sleeves are not acceptable in the swamp and marsh environment.

For other lines with low operating temperatures (below 60°C), polyethylene coating is acceptable as per **GS COR 220**.

Polypropylene can be used if economical.

Coaltar enamel shall not be used.

Cold applies tapes are not acceptable for field joint coatings. Heat shrinkable can be used.

The thickness of the pipe coating or field joint coating is depending on the pipe diameter, in compliance with the **GS COR 220** and **GS COR 221**.

According to the available inspection results, application of a three layers polypropylene coating is sufficient for the buried (cover greater or equal to 1 m) pipe sections for the prevention of top of line corrosion (TOLC).

In these cases, all exposed non-vertical pipe surfaces like doglegs but other than risers shall be heat insulated.

The thickness of heat insulation coating shall be calculated case by case knowing that the coating shall be either polyurethane or EPDM.

Polyurethane shall be applied above the anti corrosion coating which is three layer polypropylene.

A concrete coating can be applied above the EPDM coating or polyurethane coating if required.

Typical thermal conductivities are provided below:

Material	Thermal conductivity
EPDM (solid)	0.26 to 0.33 W/(m.K)
Polyurethane (solid)	0.20 W/(m.K)
Polypropylene (solid)	0.22 to 0.43 W/(m.K)



Polyethylene (solid) 0.30 to 0.43 W/(m.K)

FBE (solid) 0.26 W/(m.K)

Heat transfer coefficient (global) shall be calculated with respect to the selected coating material and thickness, and with reference to the pipe steel wall outer diameter.

8. Basic design

8.1 Scope

Basic Design shall be based on the Pre-Project study and on its respective SOR. Acceptance of the solutions and assumptions adopted may not however be compulsory since some design data could not be available at the Pre-Project step.

Basic design shall be conducted under a COMPANY approved Quality Plan.

8.2 Particular Project Specifications and Procedures

8.2.1 Particular Project Specifications

A file containing all the Particular Project Specifications (PPS) shall be compiled.

Under no circumstances the General Specification shall be changed. Changes specific to the Project shall be drafted into the Particular Project Specifications.

A list of all applicable PPS shall be made according to Project requirements, and shall cover as a minimum:

- pipeline tubes fabrication
- pipe coatings such anti corrosion and weighing coatings (in plant and on site)
- on site pipe welding
- design, fabrication and installation of cathodic protection for the pipeline
- fabrication of fittings such as flanges, elbows, valves, bends, etc.
- installation/construction of the pipeline (including supporting, anchoring, NDT etc.)
- pre-commissioning (hydraulic, calibration tests, etc.)
- valves pits
- marker posts
- positioning
- commissioning (cleaning, drying, etc.)
- civil works (ROW preparation, explosives, trenching, burying, crossings, valve pits etc.)
- instrumentation and SCADA
- telecommunication
- site-reinstatement

At the request of the COMPANY, particular points mentioned in the PPS shall be justified by references and the COMPANY shall be the sole judge of the validity of this evidence.



The Particular Specifications shall be drafted in accordance with the Total General Specifications and the works design principle.

In general, the current standards and codes of practice of the industry shall be observed.

Care shall be taken to avoid drafting of unjustified overly restrictive specifications, as this shall constrain competition among acceptable methods and means.

PPS shall be written in English and as per the relevant Total General Specifications.

8.2.2 Procedures

These specifications shall have to be supported by adequate procedures written during the Detailed Engineering. However outlines of these procedures shall be given during the Basic engineering phase.

The requested procedures is listed as follows:

- pipe laying for the shore approaches (base case)
- pipe laying in swamps
- water courses crossings
- tie-ins
- existing pipeline(s) crossing(s)

8.3 Material Take Off

A quantity survey shall be made of all items required for the construction of the SMPLs.

The bills of quantities shall be in the form of a procurement order specifying quantity, the Vendors to be consulted and references of the applicable Specifications.

A technical requisition shall be prepared for each separate procurement of materials required for the construction of the works.

The technical requisitions shall include:

- the quantity survey supported by the pipeline data sheets.
- a list of possible Vendors submitted to the COMPANY for approval
- the references of the drawings and Specifications applying to the order.

Recommendations shall be made on the contingency quantities in surplus, for each type of material, based on experience and justified by references.

These recommendations shall be reviewed by the COMPANY which shall decide policy on surpluses in the drafting of procurement orders.

A number of extra pipe lengths shall be ordered to be stored in fully specified areas for future repairs.

A dedicated cocooning procedure shall be prepared by the contractor to store these pipes for a period of time at least equal to the service life of the pipeline.

8.4 Budget

An itemised budget shall be made concerning the procurement, fabrication and installation of the Works.

8.5 Lawful Authorities Part

All administrative procedures, followed or to be followed in order to obtain approval lawful authorities and State organisations for the performance of the Project shall be described.

All notes prepared for consideration by the said authorities shall be included in the Project Analysis File.

8.6 Fixed parameters to be defined at the end of basic design

Here after is given the minimum list of essential parameters or information which shall be released at the end of the basic.

Some of them are related to any lines whatever their locations or their effluents.

Some of them are related to hot lines only where upheaval buckling problems have been identified.

This list is to be considered as different to the deliverables list as request by contract to the engineering contractor.

8.6.1 Design Part

For any lines:

- OD, WT, steel grade, corrosion allowance,
- minimum concrete coating thickness and density
- minimum submerged weight "as-laid" (to include post-laying stabilisation requirements if any)
- pigging facilities description (process and mechanical data sheets)
- anti-corrosion Coatings (type and characteristics)
- cathodic protection system (type and sizing)
- riser approach, dog legs (expansion calculations, stresses analysis, isometrics)
- special design due to the constraints linked with the drilling rigs access channels, and any other restricted/protected areas

For hot lines (where thermal response is not negligible):

- upheaval buckling calculations which shall provide additional requirements for weight, trench depth and imperfection heights; the design is to be done in such a way to give maximum flexibility on imperfection height (as it is the most difficult parameter to control),
- cathodic protection type compatible with hot lines (types and sizing)
- special requirements for Top Of Line Corrosion
- loop expansion devices (expansion, calculation, stresses analysis, isometrics)

8.6.2 Installation Part

For any lines:

- trenching method and depth,
- backfilling specification (method to backfill, definition of the backfill material, resourcing of the material, height of cover)

- laying method (typical laying means, stress analysis, laying requirements)
- description of river bank/shore approach reinstatement (when riser platform cannot be installed)
- at pipeline crossing: to define precisely extended depth, protection, marking etc...
- description of all fenders (piles, riser fenders etc...) to prevent boat collision

For hot lines (where thermal response is not negligible):

- imperfection height (maximum admissible and requested method for installation)
- loop expansion devices (expansion calculations, stresses analysis, isometrics)

8.6.3 Survey and inspection requirements

For any lines:

- equipment description (and equipment brand/type) and survey specification for pre-survey, survey of existing pipes (if any), survey during installation, survey as-built to describe the equipment allowing to measure the back-filling thickness and to specify backfilling sampling)
- specification for electronic calliper pigging for all lines in place of gauging pigs
- specification for a highly accurate pipeline location system

For hot lines (where thermal response is not negligible):

- requirements for additional equipment to check imperfection of profile during laying and trenching
- requirements for intelligent pigging of 6" OD and above hot lines with corrosive effluent.

When pigging facilities are required for inspection purposes:

- the pig traps shall be sized to accommodate the lengths of the most currently used pigs/tools.
- list of the anticipated pigs/tools shall be given by COMPANY.

The base case for these tools is:

- construction pigs such foam pigs, magnetic cleaning pigs, bi-di pigs, etc.
- construction electronic calibration pig (calliper) such ROSEN, TD Williamson, KOPP, etc., or equivalent approved by COMPANY tools
- inertial pigs for position line survey
- intelligent pigs (magnetic flux leakage) both for gas and liquid lines for future inspection

All the fittings (tees and bends) of the main line (to be inspected) shall be adapted for the passage of these tools:

- minimum bending radius shall be 5D on platforms and on current line (including expansion spools)
- tees shall be barred including tees in pig traps.
- the on-line valves shall be of full opening type and full bore.

It is important to check that the pipeline wall thickness shall not exceed the capability of the foreseen inspection tool (for magnetic flux tool).

Addition internal steps due to the various thicknesses may create unacceptable obstacles for the pig's circulation; this shall be avoided by using an internal constant diameter, and this applies especially for main export onshore gas lines and for any pipelines where pigging operations are requested more than twice a month.

To ease the location of the findings, markers shall be installed regularly on the line: every two kilometres (to be adjusted) one additional weld can be inserted in the line to generate a special signature collected at the passage of the inspection tools and recorded.

Pig launchers and receivers shall be equipped with proper (permanency to be defined by COMPANY) lifting frames (beams and sheaves) to allow safe and easy handling or recoveries of the pigs.

To allow future pipeline inspection from one intermediate platform to the next one, it is required to install facilities such flanges and valves to install temporary pig traps.

It is to be noted that during the pre-commissioning phase, the run of instrumented calliper tool(s) shall be done to control the geometry of the line (in particular the inside diameter variations).

8.7 Slug catchers, Pig Traps and Closures

8.7.1 Liquid pipelines

Scraper traps shall be subject to the same assembly requirements as per ISO 13623.

If tested separately the test Pressure (water) shall be in accordance with paragraph 6.9.10.

This test shall be conducted during 24 hours.

However doors shall be designed as per [ASME VIII](#) (or alternatively as per [BSI PD 5500](#)).

Doors shall be quick of opening type. Mechanical interlock is to be provided to avoid inadvertent opening of the door.

Special care is required for the transition parts between part under pipeline code and part under pressure vessel code (thickness).

Closure by bolted flanges is not allowed for permanent pig trap facilities.

Corrosion allowance for these "dead parts" (pig traps) shall be also given by COMPANY Corrosion specialists.

Slug catchers are not relevant for liquid pipelines.

8.7.2 Gas pipelines

Scraper traps shall be scan be considered as a particular "aerial" parts of the gas pipeline. Design factor as per ISO 13623 with location class 3 (minimum).

Doors shall be quick of opening type.

Closure by bolted flanges is not recommended for permanent pig trap facilities.

However quick opening doors not classed as standard pipeline sections should comply with [ASME VIII](#) (or alternatively with [BSI PD 5500](#)).

Mechanical interlock is to be provided to avoid inadvertent opening of the door.

Special care is required for the transition parts between part under pipeline code and part under pressure vessel code (thickness).

Closure by bolted flanges is not allowed for permanent pig trap facilities.

Corrosion allowance for these "dead parts" (pig traps) shall be also given by COMPANY Corrosion specialists.

Slug catchers i.e. liquid removal equipment shall be designed as follows depending whether the slug catcher is vessel type or multiple pipes (finger type) and depending on the inside configuration of the equipment:

	With inside welds	Without inside welds
Vessel type	BPV ASME VIII division 1 or BSI PD 5500	BPV ASME VIII division 1 or BSI PD 5500
Finger type	BPV ASME VIII division 1 or BSI PD 5500	Buried or Aerial : ISO 13623

Indication of the pipeline code versus piping code battery limit shall be given.

8.8 Future Repairs

When any pipeline is designed, future repairs shall be considered.

The design shall be repaired within an acceptable time scale if the line has great strategic importance.

Over-supply of materials should include fittings as well as line pipe, and in compliance with the set failure/repair scenarios.

8.9 Risk Assessment

A risk assessment study shall be done to define and quantify the potential risks of damage or failure of the line.

This risk assessment study shall allow to mitigate the identified risks during the design phase of the line and to give grounds for the future repairs of the line.

8.10 Methodology of design calculation

8.10.1 General

The methods, formulae and procedures given in this section are the basis for the performance of the Analysis.

Choice of other methods, formulae or procedures shall be justified by dedicated studies and supported by adequate references and COMPANY shall be the sole judge of the validity of these deviations.

Observance of the recommendations of the present General Specification shall by no means release the Contractor from his obligation to use a methodology, which enables the efficient performance of the works in a professional manner.



In particular, an overall view of the Works design development shall be maintained to follow a progression corresponding to project requirements.

To implement this, the order of performance of design and breakdown of analysis shall be changed according to needs.

8.10.2 Mechanical Analysis for Pipelines

8.10.2.1 Scope

The purpose of this analysis is to finalise the choice of the grade of steel and thickness of pipes to be used in the Works on the basis of mechanical strength under service conditions.

This shall be a detailed confirmation of the results of the Pre-Project analysis for steel pipes.

8.10.2.2 Stresses

The parameters shall be determined by considering at first the hoop stresses.

When there is a significant axial compression essential to mechanical equilibrium, the critical stress to consider shall be the equivalent stress.

8.10.2.3 Other Considerations

The mechanical resistance aspects not involving an increase in wall thickness or the specified yield stress of the steel shall be considered.

If resistance to fatigue, buckling (river crossing), static and dynamic stresses due to free spans etc. is inadequate, then the overall configuration shall be improved at first and not the mechanical properties of the pipes.

In exceptional cases where these factors shall affect pipe characteristics, they shall be identified and analysed from the beginning of the project if possible.

It shall be noted that:

- selection of the theoretical thinnest thickness is not proven to be always a good practise
- derogation to use pipes having a D/t ratio greater than 100 is to be sought to COMPANY for approval.

8.10.3 Pipeline Stability

Pipeline stability analysis shall be performed to ensure that the pipeline shall be stable during installation and in its final design position.

The pipeline to be installed on nearshore, river crossing and swamp areas are to be buried.

Their stability shall be checked:

- before trenching, i.e. pipeline lying on the ground
- just after being laid in the trench (open) the pipeline stability shall be also checked after back-filling and in service

8.10.3.1 Static stability

Static stability is related to pipelines in swamp and nearshore locations. It concerns:

- Pipelines laying directly on the ground

- Pipelines laying in a trench
- Stability of the walls of the trench

8.10.3.1.1 Stability of pipeline lying on the ground

The pipeline shall be designed so as to ensure that its embedment in the soil under its self-weight is acceptable.

The pipeline embedment shall occur due to settlement and/or bearing failure of the soil mass.

The pipeline shall penetrate to a depth where the bearing capacity of soil is equal to the vertical loads applied on the soil by the pipeline (submerged unit weight of the pipeline reduced from vertical lift-loads due to environmental forces).

The bearing capacity of the soil shall be computed using the general equation of soil mechanics proposed by TERZAGHI for very long shallow footing foundations.

The pipeline embedment shall be evaluated using step by step calculations.

8.10.3.1.2 Stability of buried pipelines

The possible flotation and settlement of the pipelines and the stability of the walls of the trench shall be checked:

8.10.3.1.3 Floatation of the pipelines

The pipeline unit weight (considering the full range of service conditions) shall be selected in order to avoid pipeline floatation.

Potential floatation of the buried pipeline shall be studied using the analytical experimental procedure developed by GHAZZALY et al (1975):

$$\gamma_{pf} = \gamma - K_f Su / D$$

Where,

K_f = Bearing capacity coefficient

Su = Undrained shear strength of backfill material

γ_{pf} = required unit weight of the pipe to resist floatation

γ = Soil unit weight

Conservative undrained shear strength values shall be selected for the soil covering the pipeline due to remoulding from installation action.

8.10.3.1.4 Settlement of the pipelines

Excessive settlement of buried pipeline shall be avoided.

The computation of this settlement shall be assessed using conventional soil mechanics principles (TERZAGHI).

8.10.3.1.5 Stability of the trench

Standard soil mechanics principles shall be applied to the verification of trench or slopes stability.

Conventional circular slope stability analysis shall be used to verify trench wall stability.

Drained and undrained analysis shall be considered.

Load cases such gravel dumps shall not be forgotten.

8.10.3.1.6 Vertical stability

The vertical stability of the pipeline is directly related to its submerged weight.

The vertical stability is ensured when the submerged weight of the pipeline is in excess of the hydrodynamic lift force

$$W_s > F_l$$

The required safety factor under vertical condition (W_s/F_l) is equal to 1.25 minimum.

When upheaval buckling is at risk, then the pipeline (empty conditions) submerged density shall not be less than 1.5

Large diameter pipelines for practical handling reasons may not be able to satisfy this last requirement.

8.10.3.1.7 lateral stability

Pipeline lateral stability is ensured when the soil resists the lateral forces imposed to the pipeline:

$$F_h > F_d + F_i$$

where,

F_n = Soil lateral resistance to pipeline movement,

F_d = Hydrodynamic drag force,

F_i = Hydrodynamic inertia force

The use of the standard COULOMB sliding friction model to represent the lateral resistance is not valid for SMPLs

The calculation method of the lateral soil resistance shall comply with the PIPESTAB or AGA soil models (WAGNER and al. - 1987, BRENNODEN and al. - 1989).

Lateral soil resistance shall be expressed as the sum of two terms.

$$F_h = F_f + F_r$$

where,

F_f = COULOMB friction term

F_r = Penetration dependent soil resistance term

The required safety factor under lateral condition ($F_h/(F_d+F_i)$) is equal to 1.25

The stability of a pipeline shall be such that it shall not move from its initial position under environmental loads, except where such movement corresponds to an allowable deformation.

The main criteria which limits the allowable deformation are:

- plastic deformation, buckling or fatigue
- coating wear
- geometric limitations

- distance with respect to other structures or obstacles.

Stability of the pipeline in flooded areas (other than river crossings) shall be also checked.

Adequate stabilisation method such as concrete weighing, additional weights, etc. shall be proposed to prevent the uplifting of the line due to its natural buoyancy (if positive).

Also the dynamic stability of the pipeline due to the slugs progress (if any) inside the line shall be checked in particular in the change of direction and aerial parts.

8.10.3.2 Dynamic stability

Pipeline dynamic stability shall be checked for detailed analysis along the pipeline.

Dynamic analysis shall include full dynamic simulation of a pipeline resting on the sea or river bed: modelling of soil resistance hydrodynamic force, boundary conditions, and dynamic response.

Pipeline stability shall be checked both during its installation and its operation.

Dynamic models developed by AGA or PIPESTAB projects or equivalent shall be used.

The pipelines laid on the sea or river bottom are subject to force caused by waves and/or currents.

The hydrodynamic forces acting on the pipe (lift force F_l , drag force F_d and inertia force F_i) shall be calculated as per [DNV RP E305](#).

8.10.4 Protection Against Internal and External Corrosion

The purpose of this analysis is to specify the coating and cathodic protection system required so as protecting the pipeline against both internal and external corrosion (and/or abrasion due to line movements).

8.10.4.1 Internal Corrosion

The requirement to protect the pipeline against internal corrosion shall be given by the COMPANY process engineer and by the COMPANY corrosion engineer.

Analysis is limited to follow the COMPANY instructions for internal coatings (including ceramics), material selection, thickness allowances, inhibitor injection, or corrosion monitoring.

8.10.4.2 External Corrosion

A complete and integrate system of protection against corrosion from environmental effects shall be specified.

The methods of protection used shall be suited to the locations (onshore, offshore nearshore, rivers, etc.) where those parts of the pipeline are located so as to ensure protection against chemical, physical and biological corrosion.

The coatings and cathodic protection systems shall be selected and analysed using the following parameters:

- service temperature and design temperature
- local environmental, chemical and biological data
- risk of mechanical damage
- coating application procedure

- compatibility of juxtaposed coatings
- soil and water resistivities
- adjacent structures and pipelines
- works service life
- facility of maintenance and repairs to coatings or anodes.
- adjacent structures and other pipelines

A particular attention shall be paid to the field joints coatings.

A detailed analysis shall be performed according to the relevant Total General Specification. COMPANY's corrosion discipline shall be consulted.

8.10.5 Thermal insulation

The requirements for thermal insulation for hot pipelines where internal top of line corrosion is anticipated shall be given by COMPANY's process and corrosion disciplines.

8.10.6 Pipeline Stress and Strain Analysis

8.10.6.1 Scope

The purpose of this analysis is to ensure that pipeline stress and strain remain within allowable limits during the entire service life, including hydrostatic testing.

Stress analysis shall be performed according to acceptance criteria of the equivalent stress design factors F_{eq} - as defined in the [ISO 13623](#).

NOTE: for non-solid metallic pipeline (composite, fibber glass, polyethylene, flexible, etc. lines) dedicated calculation methods (to be defined) are to be used.

8.10.6.2 Load Cases

Stress analysis shall be made for each part of the pipeline system (buried and unburied typical section, aerial typical section, river crossing typical section etc.).

All cases shall be analysed to make sure that the maximum stresses are within the acceptance criteria.

8.10.6.3 Elastic Limits

The calculation of the elastic limit stresses shall be analysed for each part of the pipeline system.

The wall corrosion allowances and the strength of the coatings shall not be considered in the stress analysis.

However, where these elements may decrease strength, the decrease/increase in rigidity and weight due to these elements shall be introduced into the analysis.

8.10.6.4 Collapse

Generally, this verification shall be done for submerged areas and for crossings which are the worst case for collapse.

Dedicated calculations shall be done to check that the induced combined stress shall not exceed the allowable levels.

Special attention shall be paid for drifting ices, which could result in partial collapse of the pipeline due to the loads got from ice pits.

8.10.6.5 Buckling

Buckling of pipelines under longitudinal compression shall be analysed.

If the compression thrust load is significant then elastic limits shall be re-analysed taking into account lateral deformation using large deformation analysis.

8.10.6.6 Cyclic Loads and Fatigue

The effects of all cyclic loads on the works shall be analysed.

Calculation of vibrations for lengths of pipe suspended horizontally or vertically due to effluent flow turbulence shall be made.

In addition to resonance, vibrations due to turbulence detachment or cyclic loads from water flow or wind can cause fatigue failure.

Also, a check based on the expected number of loading cycles during the works service life shall demonstrate resistance to fatigue.

As necessary a depth analysis of fatigue shall be done for section of the works suspected to be critical regarding this problem.

8.10.7 Aerial parts and above ground supported parts

Analysis of aerial parts and above ground supported parts shall be made in accordance with the above requirements.

However, the special configuration of such a part requires particular analysis of certain points, which are enumerated in this subsection.

It shall be noted that configuration with accrual riser and supports (on arrival, at departure points and at riverbanks) shall be considered.

8.10.7.1 Supports

Supports shall be defined for these parts which shall enable the line to remain within the allowable stress limits described in § 8.10.2.2.

In particular, the pipeline support's safety factor shall be at least equal to that of the pipeline; the only accepted exception is when the overall safety of the works can be improved by designing one or more supports at an ultimate strength below that of the pipeline (principal of the "fuse").

The design of the set of supports shall take into account practical operating limits concerning aerial connections and use of fixed attachments and sliding supports.

8.10.7.2 Thermal Expansion

Heat expansion is particularly significant in the analysis of aerial and above ground parts and requires in depth examination.

Specifically, the longitudinal extension of a pipeline under the effect of heat expansion and internal pressure shall be taken into account.

If necessary an expansion loop sized to absorb this deformation shall be provided.

Analysis of this device shall comply with the requirements set in § 8.10.6.

8.10.7.3 Cyclic loading

Cyclic loading on the suspended sections of the riser shall be carefully analysed in accordance with above § 8.10.6.6.

Wind and icing effects shall also be included in these calculations.

8.10.7.4 Effects due to the slugs

Effects due to the slugs, accumulation of liquid in low points, etc. shall also be taken into account.

8.10.8 Upheaval Buckling study

For all buried pipelines (gas and all other hot pipelines) when the effluent temperature received from profile temperature is greater than the soil conditions, risk of upheaval buckling phenomena shall be studied.

Local regulations may impose to bury the near-shore lines. Then, there are also great chances to get upheaval buckling phenomena for hot buried pipelines.

The stability of buried pipeline is normally ensured by the weight of the pipeline itself and by the covering materials.

The pipeline is laterally restrained by the side of ditch itself.

The natural friction of the pipeline against the cover materials should normally render the pipeline as restrained.

Calculation shall demonstrate that within the imperfection ranges of the profile of the pipeline and with the proposed cover upheaval buckling shall not occur.

For this last purpose, the only COMPANY approved engineering method is as follows:

- gather the soil data
- derive accurate soil/concrete longitudinal, vertical, and lateral friction factors; the most conservative factors shall be retained (i.e., the higher for the induced compressive force, the lower for the longitudinal expansion)
- derive a reliable shear strength corresponding to the top of the pipeline at the beginning of the cover soil.
- get the minimum sea water temperature expected during the laying operation
- get the maximum operating temperature of the line at the suspected location taking into account the thermal profile, the sun radiation and the maxi sea water temperature or soil temperature
- calculate the thermal exchange coefficient of the pipeline assembly at the suspected location
- get the soil density in pessimistic case i.e. cover soil not compacted and water saturated
- get the expected profile of the route with the heights of expected imperfections with an accuracy not smaller than 0.30 m
- perform reliable assumptions on the effectiveness of the trenching method, the effective achieved depth of trench, the effective cover weight induced by the back filling, the effectiveness of this back filling in the time.

- get the upheaval calculations as per accepted international softwares (LLYODS, Andrew Palmer and JP KENNY)
- perform a cross-check with the COMPANY's in-house software SCAUP (Pipelines & Risers discipline)

This desk study shall indicate both whether the foreseen imperfections are admissible or not and where are located the critical parts.

If the imperfections are not admissible, then preparatory civil works shall have to be performed to decrease the heights of these imperfections.

It shall be noted that in certain circumstances this maximum height of imperfection may not exceed 0.3 m.

Optionally other upheaval buckling mitigation methods to be contemplated are:

- deeper trenching
- new covering/back filling method
- new cover/backfill material
- use of mechanical additional weighing (dummy half pipe installed onto the line, chains, anchor blocks, etc..) knowing that the pipeline shall slide underneath these devices (free expansion) and that local anchoring is prohibited
- extra thickness of concrete coating.

It shall be noted that upheaval buckling shall preferably occur where the profile presents an imperfection resulting in convex shape or where the cover above the line may disappear.

Thus, upheaval buckling is more likely to occur at:

- shore approaches and landfalls,
- swampy areas prior to an anchored point of the line (natural such firm grounds or especially created such route deviation),
- eroded areas (by river or waves/current/tide actions)
- river crossings
- moving sand banks areas
- changes of thickness
- and generally for gas pipelines above 10" in OD, and said 'buried' and installed in irregular trench and with a non-proper cover.

9. Special construction requirements

9.1 Scope

This part shall develop the special cares to be taken for the construction of SMPLs - and especially aiming to give special instructions to avoid instability or corrosion problems in these areas - but does not refer to the typical tasks or items such as:

- construction camps
- lifting equipment
- welding stations
- field coating equipment



- pipe stringing
- weather hazards
- pipe storage

9.2 Pipeline Installation

9.2.1 Safety/Security

Three aspects shall be taken into account:

The **technical Safety** aspect which shall highlight the recommended design solutions to run safely the pipeline during its exploitation. In particular a pipeline overpressure preventive system (pressure relieving and pressure limiting station and devices) shall be designed and installed to protect the line.

Practical **Safety constraints during the Construction phase** shall imply to have COMPANY representatives, with adequate communication means, at each single location to follow on site activities of Contractor, even if these sites are far remote located and even if these sites are all under the responsibility of the same main contractor. This shall be already identified for the Project COMPANY manning during the Basic phase.

Safety/Security of the pipeline system regarding public activities with adequate warning signs (river crossings, roads crossings, etc.), fencing (ROW, sectionalising valves, etc.), Gates on ROW and prevention of access shall not be forgotten.

To allow easy mapping of the line (even when buried) it is recommended to install in piggyback an electrical cable non-armoured with two conductors (to sustain 28V AC / 10 Hz to 1000 Hz / 1250 mA).

The circulation shall create a magnetic field easy to be picked up by tone generator equipment.

This may apply especially for critical pipelines subject to upheaval buckling (or lateral buckling) or pipelines buried in muddy areas or all pipelines in watercourse crossings (horizontal drilled excluded) or for swamp areas; this should be cleared during the Basic Phase.

This cable shall be strapped on piggyback onto the pipeline the line by using Avon strap or equivalent; care shall be taken during the laying not to cut this cable and the cable shall be installed at the 12o/c position.

Termination shall be done in sure area as on COMPANY platform (electrical box) or on poles on shore similar to CP survey pole; bare cable arriving inland without proper protection is not allowed.

For critical offshore pipelines one end termination shall be located on the platform.

9.2.2 Pipeline Installation

Pipeline installation covers trenching operation, laying operation of the pipeline into the trench and back filling operation onto the trench.

Detailed information for the pipeline installation which shall be submitted to COMPANY approval are required on:

- the proposed construction equipment and their performance (performances rates and tolerances)
- the sequence of operation including corrective actions
- the inspection of the trench morphology,



- the monitoring of the laying within the trench,
- the monitoring of the trench back filling.

These procedures shall comply with the Total General Specifications detailed in the following sections.

Adequate measures shall be taken when handling pipes to prevent them from any damage. Special care shall be taken during transport and storage of pipes in order to avoid excessive bending and coating damage.

Pipes for pipeline shall be stored separately and sorted out by diameters, by wall thicknesses and by types of coating.

For offshore pipeline, pipeline handling procedures shall comply the **GS PLR 406**.

Full details of the various pieces of equipment, construction spread, etc., which he proposes to use for the execution of the WORK, and of the methods by which the WORK shall be accomplished shall be given to COMPANY.

Throughout the duration of the construction phase, all equipment shall be in good and serviceable condition, in ready status to perform the WORK with no lost time, and with full spread operability

As part of the contingency plans, it shall be demonstrated to COMPANY that provisions to locate and obtain spare critical equipment should the original ones be damaged are made.

All equipment shall be suitable for safe handling (as defined by procedures) in the environmental conditions of the site.

Equipment shall be in good working conditions; before the commencement of the works, COMPANY reserves the right to inspect the equipment.

Welding procedures, qualifications tests, welder qualification, weld inspections, etc., shall comply with Total General Specifications and particular specifications developed for the project.

9.2.3 Site preparations

For pipeline sections located in river crossings, swamp or onshore area, the required width of the construction pipeline route of surface vegetation (in some areas roots removal may destabilise the grounds), debris or obstructions, including fishing nets or ponds etc... shall be cleared.

Necessary authorisation shall be obtained form local authorities.

Attention shall be drawn to the potential existence of underground services; drains, cables, pipes and he shall responsible for ascertaining the presence of such obstructions.

All necessary measures shall be taken to prevent damage to these services by approved methods of working.

Soil along the pipeline route shall be graded and prepared as required to allow proper and safe installation of the pipelines and doglegs.

Record of marking shall be done.

Location of existing pipelines shall be accurately marked before site preparation. Grading over these pipelines shall be avoided.



9.2.4 Pipeline burying

The general COMPANY policy in matter of trenching and burying is:

Onshore liquid pipelines and onshore gas pipelines (on a ROW) shall be normally buried. In swampy areas lines shall be also normally buried.

Offshore service lines shall also be buried.

Decision to pre trench or to post trench the pipeline shall be taken by COMPANY on a case by case basis.

However, in certain circumstances, onshore gas or liquid pipelines such as riser parts at river crossings or expansion loops may be aerial. In this cases the lines shall be supported.

Local regulations and rules shall apply anyway.

9.2.4.1 Burying depth

Burying depth shall be evaluated on the basis of the following criteria:

- Environmental conditions
- Soil condition,
- Pipeline diameter and weight,
- Local Regulations
- Specific consideration related to upheaval – buckling,

Burying depth of the different pipeline section shall be given in the Particular Specifications, in compliance with § 7.2.9.

9.2.4.2 Burying method

Burying method shall be selected on the basis of the soil conditions, the water depth, the environmental conditions (current, wave), the pipe diameters and its characteristics, the burying depths, and the geographical and topographical conditions.

9.2.4.3 Onshore and swamp area

Onshore, standard excavators can be used on safe areas; locally, hand excavations with proper tools shall be done in critical areas.

Pre-trenching method shall be selected in onshore and swamp areas.

Excavators mounted onto swamp-buggies shall perform the trenching work in swamp area.

In swamp areas, Contractor shall perform a site visit prior to make selection of the pre-trenching tool.

Contractor is requested to propose the less aggressive environment method to perform the excavation works.

9.2.4.4 Nearshore area

9.2.4.4.1 Water depth ranging between 0 and 3 m

Pre-trenching method or post trenching method can be selected depending on the soil conditions, slopes and prevailing currents.

In very soft soils (jelly mud) where the pre trench stability can not be ensured, temporary sheet piles can be used for the stabilisation of the trench.

9.2.4.4.2 Water depth ranging between 3 and 15 m

Pre-trenching method shall be selected for competent clayey soils (undrained shear strength > 15 KPa).

Cutter-suction dredging or backhoe mounted on a barge may be proposed.

Performances of the pre-trenching shall be demonstrated method by acceptance tests to COMPANY.

Scope of these in situ tests shall be prepared to demonstrate that the expected profile of the trench, the expected progress rates and the quality of the trench (side walls, regularity, rectitude of the longitudinal profile) are achieved.

Post trenching method shall be selected for soft cohesive soil (typically undrained shear strength < 15 KPa) and non-cohesive soil (sandy or silty soils).

The jetting machine may basically consist of a remote operated underwater vehicle that may be powered from a barge, and may be mounted on tracks and self propelled.

Post trenching shall be performed with the machine straddling the pipeline.

Trench opening shall be carried out by two inclined articulated arms equipped with a series of jetting nozzles and a clearing system.

The number and diameter of nozzles shall be optimised and shall be adjusted according to the soil characteristics.

The jetting systems shall be also designed for the destruction of the soil and for the evacuation of the sediments from the trench.

The jetting system configuration shall be as follows:

- a sledge straddling the pipeline and equipped with vertical arms equipped with nozzles directed frontward and towards the central line of the trench in order to break the soil on the side and underneath the pipeline.
- the soil break is obtained by high-pressurised water.
- a pumping system aimed at evacuating destructed soil particles and lumps from the trench.
- the trench should be cleared on a distance sufficient to ensure the lowering of the pipeline.
- in cohesionless sediments the water pressure shall be sufficient to produce the fluidisation of the soil.
- the flow of water shall be adjustable for maintaining the soil in fluid state; as a base case, a minimum 250 HP power shall be devoted for the jetting and pumping equipment.

Acceptance tests shall be performed in order to demonstrate to the COMPANY the performance of the proposed jetting machine.

Scope of these in situ tests shall be prepared to demonstrate that the expected profile of the trench, the expected progress rates and the quality of the trench (side walls, regularity, rectitude of the longitudinal profile) are achieved.

The configuration of the pipeline during trenching operations shall permit acceptable free-span lengths (see stability calculations).

Mode	Undrained Shear Strength	Method
Pre-trenching	15 kPa	Not recommended
	>15 kPa	Backhoe
		Jetting/Suction
		Cutter suction dredger: stability of the trench is questionable; not applicable if roots,vegetation, debris
Post-trenching	1 to 5 kPa	Jetting: generates large trench profile
	5 to 15 kPa	Jetting/Suction
		Cutter suction dredger
		Combined methods: recommended
	> 15 kPa	To be advised

9.2.4.5 River crossings

Horizontal drilling shall be considered as basic solution for any type of river crossing, in compliance with the **GS PLR 404**.

In addition riser configuration with aerial part is also considered as basic case.

The following alternatives shall be considered if the horizontal drilling method is not feasible due to excessive distance or too short radius or too poor soil conditions, etc.

It must be noted that risks of presence of logs buried in the river sediments have to be be foreseen.

Pre-trenching method shall be selected for the following configurations :

- non navigable rivers of less than 300 meters in width,
- no risk of upheaval buckling detected (cold lines)
- competent clayey soil material (undrained shear strength > 10 KPa)

Final post trenching may be required to get smooth profile of the line, which shall be selected for the following configurations:

- soft clayey soils (undrained shear strength < 10 KPa)
- risk of up heaval buckling (hot lines)
- sandy soils

The conventional method with clamshell dredging even if properly positioned to avoid risk of accident with adjacent pipelines is provisionally acceptable:

- this method is requiring also difficult re-stabilisations of the damaged embankment
- if the line is subject to potential upheaval buckling, this method presents the main disadvantage that the profile of the trench is chaotic.
- an additional levelling method is required to insure smooth and regular profile within imperfection tolerances.

For non navigable river and creeks, there are several options depending on the configurations :

- very short crossing (maxi width to be defined depending on characteristics of the pipeline) can be accomodate with pre-built loop pipeline
- large non navigable crossings (very shallow i.e. less or equal 3 meter depth):
 - conventional method with clamshell dredging, if properly positioned to avoid risk of accident with adjacent pipelines (if any) is provisionnally acceptable
 - if the line is subject to potential upheaval buckling, this method presents the main disadvantage that the profile of the trench is chaotic due to the roughness of the tool itself
 - an additional levelling method is required to insure smooth and regular profile within imperfection tolerances.

For creeks, it will be necessary to create free flowing arrangement above the pipeline to avoid scouring, erosion, and further more fatigue problems and buckling of the pipeline.

9.2.4.6 River banks

Special cares shall be taken for the river banks prior and further to trenching operations.

As a basis case it is requested not to touch to the riverbanks. Solution with riser and piles shall be preferably selected. Construction methods may contemplate use of temporary stingers from the construction barge to cross above the embankments.

It shall be emphasised that trenches in some riverbanks may be found impossible to re-stabilise.

9.2.4.7 Correctives measures during and after burying

The corrective actions to be perform if the burying requirements are not achieved, i.e.:

- the size of the trench is not within tolerances,
- the burying depth is less than expected,
- the vertical or horizontal trench profiles are out of tolerances,
- there are logs, etc.

shall be detailed and submitted to COMPANY for approval.

9.2.5 Laying operations

Three methods shall be considered:

- conventional laying method from a pipeline laying barge
- push-pull method from a construction barge or from inland
- lifting method with use of crane/davits facilities.

The laying procedures shall be detailed together with the relevant calculations for the pipeline installation and for its control/contingencies.

For pipeline installation, the following items shall be considered:

- Pipe handling and storing
- Start and lay-down
- Abandonment and recovery
- Pipeline section fabrication
- Barge positioning (including anchor pattern)
- Pipeline positioning during laying

- Pipeline positioning in the trench
- Dog-legs and risers installation
- Tension control
- Main equipment failure
- Tie-in to other pipeline sections
- For control installation contingencies, the following items shall be considered :
- Free span control and reduction
- Stand-by, if any

Accurate location of the pipe within the trench during laying to ensure that the pipe is not over stressed shall be done.

For offshore part (pipeline not buried) free spans correction campaigns shall be performed immediately after the laying operations to prevent mechanical fatigue of the line.

9.2.5.1 Conventional laying method

The lay barge shall be equipped with a tensioner, which shall comply with the following:

- the requested performances of this tensioner shall be those of the Basic studies.
- it is mandatory not to exceed 80% of the maximum tensioning capacity
- stinger if any shall be instrumented with load cells
- the applied tension shall be constantly recorded.

9.2.5.2 Push-pull method

This method is suitable for river crossing (depending on prevailing currents), swamp areas, and shore approaches.

Pipeline shall be built directly from a barge or from ramp and installed by using a pulling winch (can be located either on the barge or on the shore for the shore approaches).

In swamps, special carry and protective devices shall be installed to prevent entering of debris, logs, etc inside the channel.

The pulling forces shall be evaluated from the pipeline weight using the soil-pipe friction coefficient; friction coefficient for pulling restart shall be used.

9.2.5.3 Lifting method

This method is suitable for crossing of narrow watercourses. The pipeline is assembled on yard and lifted with a crane. Tie-in is performed above water.

Detailed procedures to enable this method with all calculations shall be provided.

9.2.6 Back Filling Of the Trench

Pipeline shall be backfilled by material approved by COMPANY. The height of backfill shall exceed the design depth of burial to allow settlement and consolidation effects.

Back-fill material shall be selected on the basis of the following criteria:

- the pipeline settlement under the weight of the backfill material shall be acceptable,
- the upheaval buckling shall be avoided.

Engineered back-fill material composed of coarse gravel or quarried rock shall be used for the following area:

- Shore approach,

- River banks,
- Transition sections (dog-leg/pipeline, buried portion/unburied portion ...),
- Very soft clay area.

Back-fill material characteristics (type, grain size, specific gravity, etc.) shall be submitted to COMPANY for approval before any work.

The pipelines may be covered with the excavated soil in competent clayey soil area (undrained shear strength in excess of 15 kPa) or sandy soil area.

It shall be demonstrated that quality of this back-fill material is not modified during back-filling operation (poor quality, increase of water content, etc.). Acceptance test shall be performed at the satisfaction of COMPANY.

Important notes:

- natural backfilling for areas subject to potential upheaval buckling phenomena is prohibited.
- post-lay survey to insure that the quality and the thickness of the expected cover are well achieved is also compulsory; methods to measure this cover are to be proposed to COMPANY for approval.
- in swamp areas, de-watering of the channel is to be done prior to (or during) backfilling in order to insure good quality of surrounding materials.
- mechanical behaviour of the encountered soils shall be analysed to avoid over loading of the ground (consequent rupture of the adjacent ground slopes), sinking of the backfill in unconsolidated grounds or other disorders.

9.2.7 Marking

Surface marking of pipelines along the ROW shall be done; typical arrangements shall be found in the **GS PLR 403**.

Onshore or in particular areas where existing conventional marking is difficult to be kept on fixed position, special markers shall be designed and shall be physically attached to the pipeline (straps or clamps).

On riverbanks at river crossings, special warning panels both in English and in local language shall be installed to catch attention and to forbid anchoring in the vicinity of the lines.

9.2.8 Tie-in arrangement of the offshore part with the onshore part

9.2.8.1 Shore approach preparation

For pipeline subject to upheaval buckling and depending on the soil characteristics, the following actions are requested:

Alternative 1 (pre trenching) :

Installation of temporary sheet piling along the distance comprised within HAT and LAT levels or along the first 400 metres from the HAT towards LAT, the shortest length being selected.

Width of the corridor shall be 8 metres.

Purpose of the sheet piling is to insure an efficient trenching and a smooth pulling of the line only without collapse of the side of the trench or fast natural backfilling.

Sheet piles shall be removed at the completion of the tie-in.



Trench within the corridor shall then be achieved to the required depth (mini 2 m) to insure both the legal requirements and the depth required for the pipeline vertical stability.

Suction dredger or backhoe excavator can be used.

Final profile rectification shall be done by suction dredging sledge.

Other methods can be proposed.

Alternative 2 post trenching by suction dredging :

Pulling of the offshore line with adequate floatation

Installation of cofferdam at the tie-in point

Burying of the line by suction dredging (or coral breaking) at mini 2 m depth and profile survey (and rectification as necessary)

Same operation for the onshore line

Excavation within the cofferdam by suction dredging tools and lowering of the cofferdam

Water pumping and tie-in.

Note: the proper alignment of the lines is assumed to have been done correctly.

9.2.8.2 Requirements for tie-in points

Tie-in point of the offshore part to the onshore part shall not be used for change of direction of SMPLs.

The trench respecting the allowable threshold regarding the imperfections of the vertical profile shall be continuously excavated at least 150 metres away after the tie point (toward in-lands) to decrease as much as possible the conditions for upheaval buckling (when sensitive to this phenomena).

In the case where the friction forces of the offshore line are not sufficient to restrain the line then an aerial expansion device at the tie point is to be studied.

Vertical and horizontal U-shaped expansion loops are acceptable. 5 D bends are requested.

An anchoring point is normally necessary.

Anti corrosion protection of this anchorage is to be insured.

Aerial part of the frames is to be painted.

Anti corrosion coating of the aerial part of this pipeline section is normally required.

Requirement for thermal protection shall be evaluated.

If necessary, change of direction of the buried pipeline shall be done after a 150 m distance from the tie in point.

Tie-in point shall be done on the onshore/swamp part.

Although it is allowed to perform temporary partial hydrotest for the onshore/swamps part and for the offshore part, the tie-in welds nearshore/onshore (or swamps) shall not be a 'golden' weld as tested later by the whole hydrotest of the pipeline.

9.2.9 Shore approach reinstatement

At the completion of the pipeline installation and of the tie-in welds, the trench shall be back-filled with selected material.



If due to the flow regime of the river, scouring phenomena of the riverbanks is expected, then preventive measures shall be implemented.

Concrete articulated mattresses (8 m width) (recommended) shall be installed above the top cover to protect it against scouring all along the critical part of the corridor.

The weight of these mattresses is not to be considered for pipeline stability purposes.

Sheet piling shall then be removed.

Back fill material shall be install onto the line with the trench empty to insure the best strength characteristics on the 'land' part.

Re-grassing of this area shall be done (seed projection is allowed).

Re-plantation of trees (local species) on the side of the pipeline may be contemplated to insure a good ground stabilisation if it is proven that the root extension shall not be detrimental to the external coatings of the pipeline.

9.2.10 Sectionalising valves arrangements

Pipeline valves (ball valves) shall be as per the **GS PLR 403**.

For gas and condensate pipelines, there valves can be remote operated; these valves shall be easily activated in case of emergency situation, and they shall be flanged to the pipeline to ease their maintenance.

In addition valves shall be installed within a pit which is itself fenced as a basis case.

Key of lock of the fence door is recommended to be the same as for the other locks to avoid numerous keys.

When the sliding concept for the valve within the pit is retained for stability reason, then the valve shall be placed on a steel sliding plate.

Side holes on the pit box shall allow the free longitudinal movements of the pipeline.

Permanent arrangement shall allow easy installation of temporary annular plug in order to prevent the eventual back-flow of surrounding waters and the quick emptying of the rainwater.

Valves shall be located at no more than 25 m from the nearest boat landing if located near a watercourse crossing.

In area where the pit arrangement can not be suitable for practical reasons (river banks, shore approaches, swamps) then valves shall be aerial and be supported by a piled frame structure.

When sectionalising valves are located at river crossings, these valves shall be located on aerial support accessible both from river and from onshore.

Dedicated boat landing for boat access shall be built to give safe and practical access to these valves. In swamps area gratings on support shall ease the access of the operator.

Post signs (Local language and English) on the river bank shall indicate the valve locations.

Cold vent arrangement if any shall be installed at a safe distance as per COMPANY safety requirements.

It shall be noted that during construction pigging operations and in particular during the cleaning operations, these valves shall not be mounted onto the line to avoid debris accumulation within the sealing elements of the ball valve.



9.3 As-laid surveys

As laid surveys of SMPLs shall be performed as per TEC/GEO requirements.

9.4 Handover of precommissioning

The precommissioning activities shall culminate with the handover - to the COMPANY's Field Operations - of the as-precommissioned status of the SMPL, as necessary for the purposes of the commissioning activities.

The as-precommissioned handover dossier shall have as a minimum the following items:

- Route drawings
- Pipeline data register
- Alignment sheets
- Post mortem dossier

The electronic files shall be updated for the commissioning date and these files shall allow enlargements and magnifying at any scale, as necessary for any further investigations.

9.4.1 Route Drawings

The as-built route plans and profiles shall be prepared on the basis of the results of the as-built surveys.

9.4.2 Alignment sheets

The alignment sheets are drawings shall provide the following information:

9.4.2.1 Key Plan

This plan locates the section of the pipeline in question along the route.

9.4.2.2 Plan View

The plan view, scale between 1/1000 for each sheet A3 format report and adequate scale for overall general view, shall be shown using the UTM Co-ordinate System and shall include:

- scale
- kilometres point (KP) with subdivisions in hectometres (with UTM co-ordinates)
- soil nature
- orientation (North)
- joint number
- other pipelines, valves, crossings etc.
- fences
- isobaths
- tangent points and curve radii (with UTM co-ordinates)
- any obstacles
- pipeline markers (surface signs and tube markers)
- CP measurement points
- properties limits/landowners
- all other points of special interest

9.4.2.3 Elevation View

The elevation view, with vertical scale included between 1/100 and 1/500 shall be easily related to the plan view and shall indicate:

- the natural ground level,

- the top part (and bottom depending of the scale) of the pipeline versus the KP as the results of the as-built surveys, which shall be of continuous mode (non-discrete points).
- LAT level
- HAT level

Also typical crossing views of the ROW are to be given together with a key plan.

9.4.2.4 Pipeline Characteristics Table

This table shall include the characteristics of the pipeline related to the plan view such as:

- steel thickness
- steel grades
- coatings (anticorrosion and extra weighing)
- burial depth
- references to detail adjacent drawings
- etc.

9.4.3 Pipeline data sheet registers

Data sheet forms prepared during the basic engineering to give all the characteristics of the different pipes shall be updated at the end of the construction phase and gathered within a pipeline data sheet register.

9.5 Post mortem Dossier

A post mortem dossier shall be prepared by the main contractors in charge of each parts of the pipeline construction, and shall indicate the followings:

- initial planned schedule and achieved schedule
- reasons for deviations from the original schedule
- list of manpower resources (names and position down to technician levels)
- list of construction tools and appreciation of performances
- list of technical challenges and recommended methods
- list of the principal breakdowns of the construction equipment and consequences
- list of comments on Total General Specifications
- recommended improvement actions (tools, methods, manpower, organisation, etc.)

This dossier shall be returned to COMPANY's Technology Division.

9.6 Handover requirements

9.6.1 Base line Status

This shall consist of the necessary Baseline inspection so as to:

- get complete and accurate information regarding the position of critical pipelines subject to instability and to its geometrical internal conditions.
- get complete cathodic protection survey - after proper polarisation time (8 days) - to insure that there is no abnormal current leakage along the line and that the external anti corrosion coating is both in mind conditions and efficient.
- get pipeline route survey to insure proper re-instatement of the lands, embankments etc.



- insure that no creeks are created along the route of the pipeline, which may result in scouring
- Monitoring system shall be proposed to verify the efficiency of batch treatments and evolution of TOLC rate in doglegs.

Intelligent pigging shall be carried out in selected trunklines (at least two of them) within the two first years of service in order to assess the top of line corrosion rate along the line and to confirm the efficiency of the batch treatment.

Intelligent pigging shall also give useful information regarding the efficiency of external protection (coating and cathodic protection).

Regular cathodic protection surveys (yearly basis for the onshore sections and every two years for the offshore sections) shall be carried out along the trunklines and on selected flowlines.

Initial value of the impressed current being delivered shall also be recorded.

Critical line subject to upheaval buckling shall be surveyed to detect movement of the line within the first production month.

In addition, COMPANY's topographical team shall update all drawings and maps, especially reporting the as-built of the most recent constructions, as well as the provisional areas for the future constructions.

9.6.2 Typical procedures

Typical procedures which have been developed during the construction phase and which could be re-used in case of maintenance of the pipeline system or for EPRS purposes shall be gathered in a dedicated dossier and given to the COMPANY's Commissioning team.

9.6.3 Dedicated tools

Dedicated tools which were used during the construction phase and which could be re-used in case of maintenance of the pipeline system or for EPRS purposes shall be listed in a ad hoc dossier for the COMPANY commissioning team.

Existing special tools purchased by Project should be re-leased to COMPANY.

9.6.4 Contractors

Full information on contractors which were used during the construction phase (know-how) is also to be given together with names and addresses of correspondents to COMPANY commissioning team.

9.6.5 Excess material and Spare parts

For maintenance and EPRS purposes, it is requested that excess pipes, bends, fittings, spare parts etc. are properly marked, listed, protected and stored in agreed areas.