

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

MANUAL

PIPELINE ENGINEERING

PTS 31.40.00.10

JANUARY 2008



PTS Circular 2008 - 1

Subject: DESIGN AND ENGINEERING PRACTICE

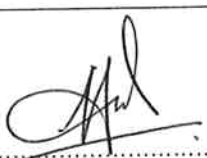
PTS No.: PTS 31.40.00.10

PTS Title: Pipeline Engineering

Issue: November 1993

Please be informed that the referred PTS has been superseded.

The PTS shall be replaced with new **PTS 20.214(January 2008) – Pipeline and Riser Engineering.**

Verification :	Endorsement :
 Signature PAU KIEW HUAI Head (Engineering) Group Technology Solution Research & Technology Division PETRONAS Position: General Manager, Engineering - PGTS	 Signature Pramod Kumar... Position: Senior General Manager, PGTS
Date: 27 Feb 08	Date: 10 March 2008

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

(CORE)

MANUAL

PIPELINE ENGINEERING

PTS 31.40.00.10

NOVEMBER 1993



PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU/Divisions in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

The right to use PTS rests with three categories of users :

- 1) PETRONAS and its affiliates.
- 2) Other parties who are authorised to use PTS subject to appropriate contractual arrangements.
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) and 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, PETRONAS disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any PTS, combination of PTS or any part thereof. The benefit of this disclaimer shall inure in all respects to PETRONAS and/or any company affiliated to PETRONAS that may issue PTS or require the use of PTS.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, PTS shall not, without the prior written consent of PETRONAS, be disclosed by users to any company or person whomsoever and the PTS shall be used exclusively for the purpose they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of PETRONAS. The copyright of PTS vests in PETRONAS. Users shall arrange for PTS to be held in safe custody and PETRONAS may at any time require information satisfactory to PETRONAS in order to ascertain how users implement this requirement.

TABLE OF CONTENTS

1.	INTRODUCTION	4
1.1	SCOPE	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	4
1.3	DEFINITIONS	5
1.4	ABBREVIATIONS	9
1.5	CROSS-REFERENCES	9
2.	APPLICATION OF CODES AND GROUP STANDARDS	10
2.1	ASME CODES	10
2.2	PETRONAS GROUP STANDARDS	10
3.	DESIGN	11
3.1	GENERAL CONSIDERATIONS	11
3.2	PIPELINE RISKS	13
3.3	PIPELINE ROUTING	15
3.4	PIPELINE STRENGTH CONSIDERATIONS	17
3.5	CROSSINGS	22
3.6	BURIAL PHILOSOPHY/PIPELINE PROTECTION	23
3.7	STABILITY	24
3.8	CORROSION PROTECTION AND MONITORING	25
3.9	INTERNAL COATINGS	27
3.10	PROVISION FOR PIGGING	28
3.11	LINE SECTIONALISING AND EMERGENCY SHUT DOWN	30
3.12	OVERPRESSURE PROTECTION	32
3.13	BRANCH CONNECTIONS AND FITTINGS	34
3.14	TELECOMMUNICATIONS	35
3.15	RECORDS	36
4.	MATERIAL PROCUREMENT	37
4.1	GENERAL	37
4.2	RE-USE OF MATERIALS	37
4.3	SPARE MATERIALS	37
4.4	LINEPIPE MATERIAL	37
4.5	FITTINGS AND SPECIAL COMPONENTS	38
4.6	ANTICORROSION COATINGS	38
4.7	CONCRETE COATING	38
4.8	RECORDS	38
5.	CONSTRUCTION	39
5.1	GENERAL	39
5.2	PIPELINE INSTALLATION	40
5.3	CONSTRUCTION HYDROTESTING	41
5.4	RECORDS	41
5.5	SAFETY AND ENVIRONMENT	42
6.	PRE-COMMISSIONING	43
7.	HAND-OVER DOCUMENTATION	44
8.	REFERENCES	45
	APPENDICES	48
	FIGURES	51

APPENDICES

APPENDIX 1	BUILDING PROXIMITY DISTANCES	49
APPENDIX 2	PIPELINE STRESSES	50

1. INTRODUCTION

1.1 SCOPE

This is a new PTS which gives minimum technical requirements and recommended practices for the design, material procurement, construction and precommissioning of onshore and offshore pipelines used for the transport of hydrocarbons and other fluids commonly transported in the petroleum, natural gas and petrochemical industries. For some fluids, in particular those of an unstable or toxic nature, additional requirements not covered in this PTS may be appropriate.

This PTS supplements and amends ANSI/ASME B31.4 and B31.8, 1992 Editions. It is recognised that, in some countries, national regulations impose codes different than the ASME codes. In those situations, this PTS provides a baseline with regard to the recommended minimum Shell requirements for pipeline engineering.

Although this PTS is primarily concerned with metallic pipeline materials, the pipeline may also consist of non-metallic materials (e.g. glass reinforced plastics), a combination of steel and plastics (flexible pipes), or steel with polyethylene lining.

In this PTS, a pipeline is defined as a system of pipes for the transportation of fluids in the liquid or gaseous phase, or a combination of both phases, between **(but excluding)** wellhead facilities, production plants, pressure boosting stations, processing plants or storage facilities. A pipeline extends from pig trap to pig trap (including the pig traps and associated pipework and valves), or, if no pig trap is fitted, to the first isolation valve within the onshore plant or the offshore installation as applicable.

The sections of pipelines crossing major rivers and estuaries, which cannot be constructed using land pipeline methods, should be treated as offshore pipelines.

The transition point between the onshore and offshore sections of a pipeline crossing the sea shore or major rivers/estuaries shores is assumed to be at the highest water mark.

Onshore and offshore flowlines connecting off-plot wellhead areas or wellhead platforms to treatment facilities are considered pipelines and are therefore included in the scope of this PTS.

The design of pipelines in arctic areas is not specifically covered in this PTS. These pipelines require to address special considerations, e.g. environmental sensitivity and permafrost aspects; specialist advice should be obtained.

Finger type slugcatchers are included in the scope of this PTS.

Figure 1 provides a diagrammatic representation of pipeline scope boundaries.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS or managed by a Group company, and to Contractors nominated by them.

This PTS is intended for use by all Functions in the Group that are involved in the design, material procurement and construction of pipelines.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this PTS which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties supplied by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may include an agent or consultant authorised to act for and on behalf of the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Assembly	An arrangement of pipes and components such as a crossing, a pig trap, a block valve station or a riser.
Barred tee	Tee-piece provided with bars across the internal bore of the branch pipe to prevent entry of a pig.
Block valve	Valve for interrupting the flow or to shut-in a section of a pipeline. A block valve is normally either fully opened or fully closed.
Branch pipe	Pipe connected to a pipeline of equal or larger diameter, using a tee-piece.
Cold bend	A bend made from linepipe at ambient temperature, normally on the construction site, using a mechanical bending machine.
Commissioning	An activity where the fluid to be transported is initially introduced into a pipeline.
Consequence	The result of an event in terms of human safety, damage to the environment and economic loss.
Design factor	Ratio of the hoop stress created by the design pressure and the SMYS of the pipeline material.
Design pressure	The internal pipeline pressure used in the determination of the pipeline wall thickness requirements.
Emergency shutdown valve	Valve for isolating a pipeline from a plant in case of emergency situations within the plant.
Flammable fluid	A flammable fluid has a flash point lower than 100 °C, with reference to EP-55000 Section 40 Part 1.
Flowline	A pipeline transporting untreated hydrocarbons and other reservoir fluids.
Fluid	A substance which is transported through a pipeline in liquid or gaseous phase, or a combination of

these.

Hot bend	A bend made under factory conditions by hot working billets, plates or pipes.
Incidental pressure	Pressure occurring in a pipeline with limited frequency and during limited periods of time. Incidental pressures include surge pressures, and thermal pressures if not occurring a significant portion of the time.
Injection line	A pipeline transporting gas, water or other fluids for injection into a well or a group of wells.
Isolation valve	Valve for isolating a pipeline from a plant connected to it.
Line pack	In a gas transmission system, the line pack is the quantity of gas in excess of the gas inventory in the system required to meet deliveries. The line pack is used to continue deliveries for some period following interruption of supply upstream.
Liquid hold-up	Quantity of liquids present in a two-phase pipeline.
Loading line	A pipeline between an onshore facility and an offshore loading facility, e.g. a single point mooring.
Maximum allowable incidental pressure	The maximum pressure that is allowed by ANSI/ASME B31.4/8 to occur in a pipeline with a limited frequency and during limited periods of time.
Maximum allowable operating pressure	The maximum pressure at which a pipeline is allowed to be operated under steady state process conditions, in accordance with ANSI/ASME B31.4/8.
Maximum operating temperature	The maximum temperature to which the pipeline or section of pipeline is expected to be exposed during normal operational activities, including start-up and shut-down operations, but excluding abnormal situations, e.g. fires.
Minimum operating temperature	The minimum temperature to which the pipeline or section of pipeline is expected to be exposed during normal operational activities, including start-up and shut-down operations, controlled blowdown, but excluding abnormal situations, e.g. pipeline ruptures.
Off-plot	A location outside designated plant boundaries.
Offtake line	A pipeline transporting fluid from a larger pipeline.
On-plot	A location inside designated plant boundaries.
Operating envelope	A defined set of key parameters or parameter ranges which must be adhered to during operation of the pipeline in order to prevent loss of technical integrity.

Overpressure protection valve	Valve intended to protect the pipeline against overpressure by preventing pressure from a source building up in the pipeline.
Pig	A device which can be propelled through a pipeline by fluid flow and normally used for cleaning, batching, inspection or other activities.
Pig trap	An ancillary item of pipeline equipment, with associated pipework and valves, for introducing a pig into a pipeline or removing a pig from a pipeline.
Pipeline	A system of pipes and other components used for the transportation of fluids, between (but excluding) plants. A pipeline extends from pig trap to pig trap (including the pig traps), or, if no pig trap is fitted, to the first isolation valve within the plant boundaries or a more inward valve is so nominated.
Pipeline code	An industry or national code written for the purpose of designing, constructing and operating pipelines.
Pipeline end manifold (PLEM)	An item of subsea equipment, comprising piping and valves, at the end of a pipeline, to which single point mooring hoses are connected.
Pipeline leak	An uncontrolled fluid release from a pipeline.
Plant	An installation, such as well-head, processing facility, pressure boosting station, storage tank, offshore platform, refinery, etc., with defined boundaries and which is not normally accessible to the public.
Pre-commissioning	A series of activities, including cleaning and possibly drying, executed to prepare the pipeline for commissioning.
Pressure equalisation line	Small bore pipe with valves to allow equalisation of pressure across a larger valve, avoiding damage to the seats of the larger valve.
Pressure relief safety valve	Valve for protecting a pipeline against overpressure by releasing fluid from the pipeline.
Remote vent line	A pipeline used for discharging light gaseous fluids to atmosphere.
Riser	A vertical, or near vertical, section in a pipeline.
Risk	The product of the probability of an event occurring and the consequences of the event when it has occurred.
Sectionalising block valve	Main valve for sectionalising a pipeline, in order to limit the release of line contents in case of pipeline leak or rupture.
Shore approach	That section of a pipeline which crosses the sea

shore, or major river/estuary shores. The shore approach includes the area of breaking waves and extends to the highest water mark.

Single point mooring (SPM)	A device for mooring a ship and transferring fluid between a pipeline and that ship.
Slugcatcher	A device located at the downstream end of a two-phase pipeline, for the primary separation of the liquid and gas phases, and the temporary storage of liquids generated by pigging and transient flow conditions. There are two types of slug catchers: the vessel type and the finger type.
Specified minimum yield stress (SMYS)	The level of stress which produces 0.5 percent total strain (API definition). This stress is specified by the Principal and guaranteed by the Manufacturer/Supplier.
Sphere	A spherical shape pig, used for batching and liquid hold-up removal in two-phase pipelines.
Sphere tee	A jacketed tee-piece with a perforated inner pipe to prevent entry of a sphere into the branch pipe.
Spurline	A pipeline transporting fluid into a larger pipeline.
Stable fluid	With reference to EP-55000 Section 40 Part 1, a stable fluid has an NFPA reactivity grade number of zero.
Surface safety valve	Valve, part of the well-head assembly, applied as isolation valve between flowline and wellhead.
Surge pressure	Pressure due to mass flow velocity changes, caused by operational activities, e.g. valve closures, pump shut-down or start-up.
Technical integrity	Technical integrity of a facility is achieved when, under specified operating conditions, there is no foreseeable risk of failure endangering safety of personnel, environment or asset value.
Test pressure	The pressure at which the pipeline will be or has been tested for strength.
Thermal pressure	Pressure due to thermal effects on the fluid in the blocked-in pipeline or blocked-in pipeline sections.
Toxic fluid	With reference to EP-55000 Section 40 Part 1, toxic fluids include all fluids in the slightly toxic, toxic and highly toxic categories.
Trunkline	A main transmission pipeline to which spurlines and offtake lines may be connected.
Two-phase pipeline	Pipeline transporting fluids where both the liquid phase and the gas phase are present at pipeline pressure and temperature conditions.

1.4 ABBREVIATIONS

CP	Cathodic protection
DN	Diameter nominal
EIA	Environmental impact assessment
ESD	Emergency shutdown
GRP	Glass reinforced plastics
GRE	Glass reinforced epoxy
HIPS	High integrity protection system (against overpressure)
LPG	Liquefied petroleum gas
MAOP	Maximum allowable operating pressure
MESC	Materials and Equipment Standards and Code
NFPA	National Fire Protection Association
NGL	Natural gas liquids
PE	Polyethylene
PLEM	Pipeline end manifold
PSE	Shell Product Safety and Environmental Conservation Committee
QRA	Quantitative risk assessment
SMYS	Specified minimum yield stress

1.5 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (8.).

2. APPLICATION OF CODES AND GROUP STANDARDS

2.1 ASME CODES

The fluid transported in the pipeline should be categorised in one of the following four groups, depending on its hazard potential:

- **Category A:** Non-flammable, stable and non-toxic fluids which are liquid at prevailing ambient temperature and atmospheric pressure plus 0.5 bar, i.e. the vapour pressure is lower than 1.5 bar (abs) at ambient temperature. Example: water, slurries.
- **Category B:** Flammable, or unstable or toxic fluids which are liquid at prevailing ambient temperature and atmospheric pressure plus 0.5 bar, i.e. the vapour pressure is lower than 1.5 bar (abs) at ambient temperature. Example: stabilised crude, gasoil.
- **Category C:** Non-flammable, stable and non-toxic fluids which are gases or a mixture of gas and liquid at prevailing ambient temperature and atmospheric pressure plus 0.5 bar, i.e. the vapour pressure is higher than 1.5 bar (abs) at ambient temperature. Example: nitrogen, carbon dioxide.
- **Category D:** Flammable, or unstable or toxic fluids which are gases or a mixture of gas and liquid at prevailing ambient temperature and atmospheric pressure plus 0.5 bar, i.e. the vapour pressure is higher than 1.5 bar (abs) at ambient temperature. Example: natural gas, liquid petroleum gas, ammonia.

Flammability, stability and toxicity are defined in [\(1.3.2\)](#).

Pipelines carrying category **A** and **B** fluids should be designed and constructed in accordance with ANSI/ASME **B31.4** and the additional requirements of this PTS.

Pipelines carrying category **C** and **D** fluids should be designed and constructed in accordance with ANSI/ASME **B31.8** and the additional requirements of this PTS.

NOTE: Liquid petroleum gas and anhydrous ammonia, which are covered by ANSI/ASME B31.4, fall under category D. Pipelines transporting these products therefore should be designed to ANSI/ASME B31.8.

2.2 PETRONAS GROUP STANDARDS

The PETRONAS standards related to the design, material procurement, construction, and precommissioning of pipeline systems are referenced in this PTS (8.1). For topics which are not specifically covered in the Group standards, the Contractor may utilise the external standards referenced in ANSI/ASME B31.4 and B31.8, after consultation with, and approval by, the Principal.

[Figure 2](#) shows the hierarchical organisation of existing and planned Group standards related to pipelines.

3. DESIGN

3.1 GENERAL CONSIDERATIONS

3.1.1 Introduction

The pipeline shall be designed in accordance with the relevant sections of ANSI/ASME B31.4/8, supplemented by this chapter (3).

The pipeline shall be designed taking into consideration the operating conditions and requirements over its entire projected life cycle including final abandonment, i.e. the maximum planned throughput and turn-down, the characteristics of the fluids to be transported, the pressure and temperature requirements, the mode of operations, the geographic location, and the environmental conditions.

3.1.2 Hydraulic design

In order to determine the possible range of operational parameters of the pipeline, a hydraulic analysis should be performed. For a given pipe size, fluid properties and flow rate, the hydraulic analysis should provide the pressure and temperature profiles along the pipeline for steady state and transient conditions. Full account shall be taken of possible changes in flowrates and operational modes, over the complete operational life of the pipeline.

The hydraulic analysis should provide data to address: surge pressure during shut-down of a liquid line, turn-down limitations and inhibition or insulation requirements to prevent wax or hydrates deposition, effect of flow conditions on the efficiency of corrosion inhibitors, liquid catching and slug control requirements at the downstream end of two phase lines.

The normal range of flow velocities is 1 to 2 m/s in liquid lines, and 5 to 10 m/s in gas lines. Continuous operations above 4 m/s for liquids and 20 m/s for gases should be avoided; lower units may apply to fluids containing solid particles, where maximum velocities will be dictated by the occurrence of erosive conditions.

NOTE: Liquid lines containing a separate water phase, even in small quantity (e.g. 1% water cut), should not be operated at too low velocities (typically below 1 m/s). This is to prevent water dropout which may lead to a corrosive situation.

For liquid lines, it is sometimes advantageous to adjust the design pressure along the route, depending on the patterns of the hydrostatic pressure and the friction pressure loss. Great care should be applied in the definition of the various sections and associated design pressures to determine whether, under any operations scenario, overpressurisation of one section is possible by the adjacent sections.

For gas pipelines, sections of decreasing design pressure are not recommended in general, because the slight cost benefit is unlikely to outweigh the lost advantage of line packing and thus loss of system availability.

3.1.3 Pipe material selection

The selection of the pipeline material type is a fundamental issue to be decided at the conceptual design stage of a pipeline project. The most frequently used pipeline materials are metallic. Non-metallic materials (e.g. GRP/GRE, flexible pipe) may be cost effective for specific applications, especially when the fluid is corrosive.

The occurrence and rate of internal corrosion is governed by a variety of process conditions which include:

- Corrosivity of the fluid, in particular due to the presence of water combined with hydrogen sulphide (sour corrosion), carbon dioxide (sweet corrosion), or oxygen. Temperature and pressure can have a great impact on the corrosion rates.
- Velocity of the fluid, which determines the flow regime in the pipeline. In pipelines transporting fluids containing water, too low velocities lead to settlement of water, which may lead to bottom of pipe internal corrosion; too high velocities can increase the overall corrosion rate and also destroy any protective scale or inhibitor films.

- Deposition of solids, which may prevent adequate protection by inhibitors, and can create anaerobic conditions for the growth of sulphate reducing bacteria.

The potential long-term impact of corrosion shall be considered during design (3.8), and it shall be demonstrated that the pipeline can remain fit-for-purpose throughout its lifetime.

**Amended per
Circular 33/04**

When sour service conditions are foreseen, as specified in ISO 15156 or NACE MR0103, as applicable, the linepipe material and other materials shall be specified to resist sour service, regardless of whether or not the fluid is to be dehydrated.

- NOTES:
1. ISO 15156 shall apply to oil and gas production facilities and natural gas sweetening plants. NACE MR0175 is equivalent to ISO 15156.
 2. NACE MR0103 shall apply to other applications (e.g. oil refineries, LNG plants and chemical plants).

Carbon steel linepipe material may be used in "light" sweet corrosive conditions (typically where corrosion rates would not exceed 0.5 mm/year without inhibition), with appropriate corrosion allowance and inhibitor injection, regular high resolution intelligent pig monitoring, and under strictly controlled operating conditions. Corrosion allowances in excess of 3 mm shall not be considered without a detailed analysis by corrosion specialists. Materials able to resist sweet corrosion include duplex stainless steels and carbon steels with internal austenitic cladding.

Internal coatings cannot be relied on for complete prevention of corrosion. Internal lining (e.g. polyethylene) can be applied for internal corrosion protection (3.8.2).

Conditions which may cause pipewall erosion shall be avoided.

3.1.4 Operating philosophy

For the predicted life cycle conditions, the design shall take due account of operations, inspection and maintenance requirements, as well as established operating philosophy and practices, agreed in advance with the personnel responsible for the operation of the pipeline. These include manning levels for the operation, integrity monitoring and maintenance of the pipeline system, the requirements for telecommunications and remote operations, means of access to the onshore right of way, etc.

The design of pipelines which are continuously in operation should address the requirement for bypass at components which need regular maintenance.

General guidance on Operations Philosophies and Policies is presented in EP 87-1009.

3.2 PIPELINE RISKS

3.2.1 General

The risk associated with the pipeline, in terms of the safety of people, damage to the environment, and loss of income, depends on the expected failure frequency and the associated consequence, which is directly related to the type of fluids transported and the sensitivity of locations of the pipeline. In this context, pipeline failures are defined as loss of containment.

The potential pipeline failures, causes and their consequences, should be inventorised and taken into account in the design and the operating philosophy. The most common pipeline threats which may lead to the loss of technical integrity are given below.

- Internal corrosion and hydrogen induced cracking (HIC).
- Internal erosion.
- External corrosion and bi-carbonate stress corrosion cracking.
- Mechanical impact, external interference.
- Fatigue.
- Hydrodynamic forces.
- Geo-technical forces.
- Growth of material defects.
- Overpressurisation.
- Thermal expansion forces.

Notwithstanding the requirements of the ANSI/ASME B31.4/8 and this PTS, the factors which are critical to public safety and the protection of the environment should be analysed over the entire life of the pipeline, including abandonment. The risk should be reduced to as low as reasonably practicable, with the definite objective of preventing leaks. The level of risk may change with time, and it is likely to increase to some extent as the pipeline ages.

Amended per
Circular 60/03

General safety design aspects are provided in EP 95-0230.

3.2.2 Safety risk assessments

ONSHORE PIPELINES

A formal quantitative risk assessment (QRA) should be carried out in the following situations with the location classes as defined in (3.3.3):

- Fluid category B and C in location classes 3 and 4.
- Fluid category D in all location classes.

The assessment should confirm that the selected design factors (3.4.1) and proximity distances (3.3.4) are adequate.

OFFSHORE PIPELINES

A formal quantitative risk assessment (QRA) shall be carried out for pipelines connected to permanently manned offshore complexes, except for pipelines transporting category A fluids. The necessary riser protection and safety systems shall be derived from this assessment.

The risk depends firstly on the expected frequency of failure, due to internal and external corrosion, external loading (e.g. impacts, settlement differences, free spans), material or construction defects, and operational mishaps. Secondly, it depends on the consequences of the failure, based on the nature of the fluid in terms of flammability, stability, toxicity and polluting effect, the location of the pipeline in terms of ignition sources, population densities and proximity to occupied buildings, and the prevailing climatic conditions. The expected frequency of failure and the possible consequences may be time-dependent and should be analysed over the entire life of the pipeline.

Risks levels can be reduced by using lower design factors (e.g. higher wall thickness or stronger steel), rerouting, providing additional protection to the pipeline, application of

facilities to minimise any released fluid volumes, and controlled methods of operation, maintenance and inspection.

NOTE: Pipelines with a wall thickness lower than 10 mm are susceptible to penetration, even by small mechanical excavators. External interference by third parties is a major cause of pipeline failures. Specific precautions against this type of hazard should be addressed; this is particularly relevant to onshore pipelines transporting category C and D fluids.

Amended per
Circular 60/03

A methodology for quantitative risk assessments is presented in EP 95-0352.

3.2.3 Environmental impact assessments

An environmental impact assessment (EIA) shall be carried out for all pipelines or groups of pipelines. Guidance is presented in the Shell PSE EIA Guide.

EIA is a process for identifying the possible impact of a project on the environment, for determining the significance of those impacts, and for designing strategies and means to eliminate or minimise adverse impacts.

An EIA should consider the interaction between the pipeline and the environment during each stage of the pipeline life cycle. The characteristics of the environment may affect pipeline design, construction method, reinstatement techniques, and operations philosophy.

3.2.4 Economic risk

The economic risk is associated with deferment of income, cost of repair, and other costs such as liabilities to the public and clean-up costs. The economic risk should be evaluated for each phase of the pipeline operating life, and should be compatible with the overall objectives of the Principal.

3.3 PIPELINE ROUTING

3.3.1 Introduction

The selection of the route shall take full account of the associated risks (3.2), particularly safety and environmental risks, the accessibility for maintenance and inspection, as well as normal direct cost considerations.

3.3.2 Surveys

Detailed survey data should be available prior to finalising the pipeline route and carrying out detailed design. These data include:

ONSHORE PIPELINES

- Population and building densities for the establishment of location classes (3.3.3), location of inhabited buildings, taking into account any future land development plans.
- Topographical data, location of rivers, roads and railways, including type and density of traffic.
- Records of any existing special features which will need reinstatement after construction is completed.
- Soil investigation for foundation design (burial and/or supports design), subsidence areas (e.g. due to mining activities).
- Soil resistivity for cathodic protection design.
- Environmental data (climatic, floods, earthquakes, landslides, currents at river crossings, vegetation, fauna).

OFFSHORE PIPELINES

- Seabed topographical data, location of rock/coral outcrops.
- Soil investigation for foundation and on-bottom stability design.
- Fishing, shipping (and other sea users) activity data.
- Environmental data (climatic, currents, waves, bathymetry, earthquakes, landslides).
- Third party facilities and concession areas.

3.3.3 Establishment of location classes for onshore pipelines

Based on the survey data, appropriate location classes shall be identified along the pipeline route for pipelines transporting category C and D fluids, in accordance with ANSI/ASME B31.8 Article 840.2. There is no specific requirement for pipelines transporting category A and B fluids, apart from access requirements during construction and for maintenance and emergency services during operations.

ANSI/ASME B31.8 identifies 4 location classes, ranging from location class 1 (sparsely populated areas) to location class 4 (densely populated areas).

Since location classes are used for the determination the design factor (3.4.1), the route selection shall take due regard for the cost impact on pipeline sections in location classes of higher category (e.g. class 3 and class 4).

3.3.4 Proximity to occupied buildings (onshore pipelines)

Compared to pipelines transporting category A and B fluids, pipelines transporting category C and D fluids constitute potentially higher hazards to people nearby. There are no provisions in ANSI/ASME B31.4/8 to cover this, apart from the location classes defined in (3.3.3) which only address population densities. For the purpose of initial routing, Appendix 1 provides guidance for establishing minimum distances of pipelines from occupied buildings depending on the type of the fluid, the pipeline diameter and its maximum operating pressure. Final routing should be established following the pipeline safety assessment (3.2.2).