

DEP SPECIFICATION

PIPELINE ENGINEERING

(AMENDMENTS/SUPPLEMENTS TO ISO 13623)

DEP 31.40.00.10-Gen.

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DESIGN AND ENGINEERING PRACTICE

DEM1



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PREFACE

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These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

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

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PART I INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, material procurement, construction, testing, operation, maintenance and abandonment of rigid steel pipelines (both onshore and offshore) used for the transport of hydrocarbons and other fluids.

This DEP is not applicable to non-metallic pipelines or unbonded flexible pipes, which are covered in separate DEPs.

This DEP is based on ISO 13623:2009. Part III of this DEP amends, supplements and deletes various clauses of ISO 13623:2009. Part III follows the clause numbering of ISO 13623 for easy reference.

All clauses of ISO 13623 not modified by this DEP remain valid as written.

For pipelines that carry some fluids, in particular those of an unstable or very toxic nature (see definition in DEP 01.00.01.30-Gen.), additional requirements not specifically covered in this DEP may be appropriate.

In addition to this DEP, DNV-RP-J202: applies for design and operation of CO₂ pipelines.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2015; see (1.5) regarding the main changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP 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, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, 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 that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Delegated Technical Authority	Person who has received delegated authority to approve derogations from the process safety requirements from the Head of Shell P&T.
Derogation	Authorised variance or exemption from a Process Safety requirement, with specified conditions.
Barred Tee	Tee-piece provided with bars across the internal bore of the branch pipe to prevent entry of a pig.
Branch Pipe	Pipe connected to a pipeline of equal or larger diameter, using a tee-piece or welded branch connection.
Cold Bend	Bend made from line pipe at ambient temperature, normally on the construction site, using a mechanical bending machine.
Deep Water	Water depth in excess of 300 m, unless specified otherwise by the Principal in the project specifications.
DEFINE	Engineering and design activities, following the SELECT stage, where a project is given further technical definition and where a job specification can be compiled for the preparation of tender documents. This is also known as Front End Engineering and Design (FEED)
Emergency Shutdown Valve	Valve for isolating a pipeline from an onshore plant or offshore platform in case of emergency situations within the plant or platform.
EXECUTE	Engineering and design activities, following the DEFINE stage, where detail design, procurement, construction and commissioning are performed prior to handover to operations.

Term	Definition
Flowline	In-field pipeline transporting untreated hydrocarbons and other reservoir fluids, or a pipeline used to inject gas into a reservoir (gas injection flowline) or a pipeline to inject water into a reservoir (water injection flowline).
Flow Assurance	Measures to be taken to ensure that a pipeline can operate within the specified operating window during its lifetime. Such measures are to be detailed during DEFINE to prevent, e.g. hydrate formation, formation of wax etc. Flow assurance is an exercise requiring input from various disciplines, such as process, hydraulic pipeline design and mechanical pipeline design, to ensure that all aspects are fully considered and an integrated solution is developed.
Induction (hot) Bend	Bend made under factory conditions by hot working 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 routinely or for a significant period.
Integrity	Condition that is achieved when, under specified operating conditions, the risk of failure that could endanger the safety of personnel, the environment, or asset value is tolerable and has been reduced to a level that is ALARP.
Isolation (or block) Valve	Valve used to interrupt the flow or to isolate one section of a pipeline from an adjacent section or a facility connected to the pipeline. An isolation valve is normally either fully opened or fully closed. Also referred to as a block valve.
Jumper	Short subsea section of pipe provided with mechanical connectors for the diverless connecting of e.g., a wellhead to the end of a flowline.
Line Pack	Quantity of gas in a gas transmission system in excess of the minimum gas inventory 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 multi-phase pipeline.
Maximum Operating Temperature	Maximum temperature to which the pipeline or section of pipeline is expected to be exposed during planned operational activities, including start-up and shut-down operations, but excluding abnormal situations, e.g., fires.
Operating Envelope	Defined set of parameters or parameter ranges that must be adhered to during operation of the pipeline in order to prevent loss of technical integrity and maintain flow.
Pig	Device that can be propelled through a pipeline by fluid flow and is normally used for cleaning, batching, inspection or other activities.

Term	Definition
Pig Trap	Ancillary item of pipeline equipment, with associated pipework and valves, for inserting and launching a pig into a pipeline or receiving and removing a pig from a pipeline.
Pipe-In-Pipe (PIP)	Single flow line, provided with an outer steel carrier pipe and annulus filled with insulation for reasons of flow assurance.
Pipeline Leak	Uncontrolled fluid release from a pipeline.
Plant	Facility such as a well-head, processing facility, pressure boosting station, storage tank, offshore platform, refinery, etc., with defined boundaries and that is not normally accessible to the public.
Pre-Commissioning	Series of activities, including cleaning and possibly drying and inerting, executed to prepare the pipeline for commissioning.
Process Safety	Management of hazards that can give rise to major accidents involving the release of potentially dangerous materials, release of energy, such as fire or explosion, or both.
Risk	Product of the probability of an event occurring and the consequences of the event when occurring.
SELECT	Stage in the design where a high level of definition is given to allow an early assessment of technical and economical feasibility of a project. The Basis for Design document (BfD) is produced in the SELECT stage.
Shore Approach	Section of a pipeline that crosses the sea shore, or major river/estuary shores. The shore approach includes the area of breaking waves and extends from the lowest to the highest water mark.
Slug Catcher	Device located at the downstream end of a multi-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.
Sphere	Spherical pig used for batching and liquid hold-up removal in two-phase pipelines.
Sphere Tee	Jacketed tee-piece with a perforated inner pipe to prevent entry of a sphere into the branch pipe.
Surge Pressure	Pressure due to mass flow velocity changes caused by operational activities, e.g., valve closures, pump shut-down or start-up.
Very Toxic – acute, chronic or environment (substances)	Substances that are very hazardous for the environment or human health, as specified in DEP 01.00.01.30-Gen.

1.3.3 Abbreviations

Term	Definition
ALARP	As Low As Reasonably Practicable
BFD	Basis for Design
CP	Cathodic Protection
CTOD	Crack Tip Opening Displacement
DN	diameter nominal
DP	Dynamically Positioned
EIA	Environmental Impact Assessment
ESD	Emergency Shutdown
FEED	Front End Engineering and Design
GRE	Glass Reinforced Epoxy
GRP	Glass-Reinforced Plastic
HFV	High Frequency Welded
HIA	health impact assessment
HIC	Hydrogen Induced Cracking
HSAW	helical submerged arc welded
HPHT	high pressure and high temperature
ID	Inside Diameter
IPF	Instrumented Protective Function, now known as SIF (Safety Instrumented Function)
LDT	Lower Design Temperature
MAIP	Maximum Allowable Incidental Pressure
MAOP	Maximum Allowable Operating Pressure
MESC	Materials and Equipment Standards and Code
MOP	Maximum Operating Pressure
MSP	maximum source pressure
NPS	Nominal Pipe Size
OD	Outside Diameter

Term	Definition
OOD	out-of-roundness
PIP	Pipe-In-Pipe
PLEM	Pipe Line End Manifold
PN	nominal pressure rating
QRA	Quantitative Risk Assessment
RIV	Riser Isolation Valve
RTP	reinforced thermoplastic
SAW	submerged arc welded
SIA	social impact assessment
SMYS	Specified Minimum Yield Strength
SSCC	sulphide stress corrosion cracking
SSIV	Sub Sea Isolation Valve
t	nominal pipe wall thickness

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (Part IV).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a minor revision of the DEP of the same number dated February 2015. The following are the main, non-editorial changes.

Section/Clause	Change
All	Restructured and clarified requirements, enforced use of shall/should/may for normative statements.
5.6	DEM1 requirements rephrased and restructured to improve clarity.
6.11.3	'Managing Risks' text aligned with PSBR 2.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

PART II GENERAL

1. Part III of this DEP is written as amendments and supplements to ISO 13623:2009. Wherever reference is made to ISO 13623, it shall be understood to mean ISO 13623:2009 as amended/supplemented by this DEP.
2. For ease of reference, the clause numbering of ISO 13623 has been used throughout Part III of this DEP.
3. Clauses in ISO 13623, which are not mentioned in this DEP, shall remain valid as written.
4. Where national legislation requires the use of a standard other than ISO 13623, this DEP shall be read as providing the minimal Shell requirements that shall be applied for the safe design, installation and operation of a pipeline system and shall be subject to approval of the Principal and documented in the BfD during the SELECT stage. In case of conflicts between this DEP and national and/or local regulations, refer to (Part I - (1.2)).
5. This DEP allows use of alternative pressure design calculations as per API RP 1111 for deepwater projects or DNV-OS-F101 for offshore pipelines, as an alternative to pressure design calculations per ISO 13623.

PART III AMENDMENTS/SUPPLEMENTS TO ISO 13623

1 Scope

Add to this clause:

1. 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. Refer to (6.14.4).
2. Slug catchers, including associated pipework and valves, are deemed to be part of a pipeline, unless otherwise specified by the Principal.
3. The asset class for "pipelines and subsea systems", covering both onshore and offshore assets, is defined in (4) of DEP 31.40.00.11-Gen.

3 Terms, definitions and symbols

Add to this clause:

1. Definitions and abbreviations in (Part I - (1.3)) of this DEP shall also apply.

4 General

4.1 Health, safety and the environment

Add to this clause:

1. HSE associated with the design, construction (including equipment), testing, operation, maintenance and abandonment of the pipeline system shall be managed in accordance with the requirements of the Principal's HSE Management System.
2. An assessment shall be carried out of the potential public safety, environmental, social and health impact of the proposed pipeline and where appropriate alternative routes and/or designs shall be evaluated. Mitigation, integrity management and monitoring measures shall also be addressed. Refer to (5.6), (6.2.1.2) and (6.2.1.3).

5 Pipeline system design

5.2 Categorization of fluids

Add to this clause:

1. The term "toxic" shall be understood to include the classification "very toxic – acute, chronic or environment", as defined in DEP 01.00.01.30-Gen.

5.3 Hydraulic analysis

Add to this clause:

1. The hydraulic analysis shall evaluate all possible changes in flowrates and operational modes, over the complete operational life of the pipeline based upon data provided by the Principal.
2. The hydraulic analysis shall also consider:
 - a. Surge pressure during shut-down or start-up of a pipeline transporting liquids;
 - b. Liquid catching and slug control requirements at the downstream end of multi-phase lines;
 - c. All relevant flow assurance aspects (asphaltenes, hydrates, wax, scales, emulsions, foaming and chemical compatibility, including transport of any solids present in the fluid);
 - d. Turn-down limitations with inhibition or insulation requirements to prevent wax deposition or hydrate formation;
 - e. Flow regimes and fluid velocities to allow their effect on pressure drop, hold-up and the efficiency of corrosion inhibitors to be determined;
 - f. Minimum fluid velocities (e.g., which may be required for intelligent pigging operations);
 - g. Benefit of internal flow coating of gas transmission lines after allowing for possible fouling.
 - h. Depressurisation and re-pressurisation of pipelines transporting Category C, D and E fluids and slug catchers.
3. The following requirements also apply:
 - a. Pipelines conveying a liquid should be sized so that the normal range of flow velocities is 1 m/s – 2 m/s (3.3 – 6.6 ft/s);
 - b. Continuous operation above 4 m/s (13 ft/s) shall be avoided for pipelines conveying a liquid;
 - c. Incidental operation of liquid pipelines above 4 m/s (13 ft/s) shall be evaluated and documented (e.g., surge analysis);
 - d. Unlined carbon steel pipelines transporting category B liquids containing a separate water phase, even in a small quantity (e.g., 1% water cut), shall not be operated at low velocities (below 1.5 m/s (5 ft/s)). This is to prevent water dropout, which may lead to a corrosive environment:
 - i. Approval by the Principal shall be obtained on the required minimum velocity or alternative corrosion mitigation measures to be applied.

When transporting light crude oils or condensate, a minimum velocity of 1.5 m/s (5 ft/s) in crude (higher in lighter fluids) may not be sufficient to prevent water dropout.
 - e. Pipelines conveying gas should be sized so that the normal range of flow velocities is 5 m/s – 10 m/s (16 – 32 ft/s).
 - f. Continuous operation of gas pipelines above 20 m/s (65 ft/s) shall be avoided.
4. At water cuts higher than 20%, flow velocity is no longer an issue as water wetting of the pipe wall will always occur. Alternative means of corrosion mitigation shall be evaluated as part of the overall Material Selection Report.

5. A corrosion management strategy shall be developed based on the expected water drop-out in the pipeline during low flow conditions.
For intelligent pigging operations, a minimum velocity of 1 m/s (3.3 ft/s) is recommended unless stated otherwise by the intelligent pig Manufacturer/Supplier.
6. For pipelines conveying fluids containing solid particles, the maximum velocity shall evaluate the potential for erosion and results documented in the Material Selection Report:
 - a. The presence of solids in the fluid shall be specified in the BfD during SELECT.
7. For pipelines that will require the use of hydrate inhibitors, possibly in combination with other chemicals, shall be subject to approval from the Principal's flow assurance and condensate/water treatment specialists.

5.4 Pressure control and overpressure protection

1. In case overpressure protection is provided by relief valves, refer to DEP 80.36.00.30-Gen. for requirements.
2. In case overpressure protection is provided by source-isolation valves, refer to DEP 32.80.10.10-Gen. for requirements.
3. When existing pipeline systems are extended, e.g., by adding a new branch line, the pressure protection of the whole pipeline system shall be reviewed to confirm that:
 - a. over-pressurisation of the system from the new branch line is not possible;
 - b. the extended system has a consistent design pressure.

5.5 Requirements for operation and maintenance

Add to this clause:

1. The requirements for operation and maintenance of the pipeline system will be established in outline in the BfD during the SELECT stage.
2. During DEFINE and EXECUTE stages, the requirements for operation and maintenance of the pipeline system shall be further detailed, refer to DEP 31.40.00.11-Gen. for requirements.

Add to 7th bulleted item:

1. Refer API RP 1130 and API RP 1175 and (6.12) and (13.3.4) for requirements regarding pipeline leak detection systems.

Add to 12th bulleted item:

1. The requirement to depressurise and re-pressurize a pipeline containing a Category C, D or E fluid and slug catcher shall be assessed during the DEFINE phase and:
 - a. establish the minimum temperature and material requirements;
 - b. define the depressurisation or repressurisation rate and durations;
 - c. consider the impact on the associated facilities;
 - d. refer to DEP 30.10.02.31-Gen. for requirements to prevent brittle fracture and (6.11.1, items 11-14).

5.6 Public safety and protection of the environment

Add to this clause:

1. The factors that are critical to public safety and the protection of the environment SHALL [PS] be identified and analysed over the entire life of the pipeline, including abandonment, taking into account any potential changes in the level of risk over time (e.g., due to encroachment of built-up areas).

Section 6.2.1.1 of ISO 13623 lists some factors that could apply.

2. The risk shall be reduced to as low as reasonably practicable (ALARP), with the definite objective of preventing leaks.
3. The risk reduction measures and ALARP achievement shall be fully documented, implemented and maintained throughout the project life.

6 Design of pipeline and primary piping

6.1 Design principles

Replace first 1st paragraph with:

1. The extent and detail of the design shall demonstrate that the integrity, in line with DEP 31.40.00.11-Gen. and the relevant operating integrity management system, and serviceability required by this DEP can be maintained during the design life.

Add to this clause:

1. For reliability or strain based limit state design methods, refer to DEP 31.40.10.18-Gen. for requirements.
2. Reliability or strain based limit state design methods shall only be used to confirm the safety of a design when no established (e.g., deterministic) guidance is available. Such cases may include:
 - a. design for extreme high loads with low probability of occurrence during the design life such as seismic loads at a fault crossing or loads from the impact of ice keels;
 - b. design for extreme loads in lieu of deterministic design, such as for external pressure design in deep water;
 - c. situations where strain based criteria are applied but the resistance capability of the pipe is uncertain, e.g., due to variations in pipe wall thickness or strength of the pipe material;
 - d. hot buried pipelines where the wall thickness requirement would be governed by the equivalent stress criterion, instead of the hoop stress requirement.
3. Where use is made of reliability-based limit state design principles, the impact on welding and materials shall be evaluated during the DEFINE stage.

Use of reliability-based limit state design methods has impact on development and testing of materials and welding.

4. Reliability-based limit state design methods shall not be used to circumvent or recalibrate functional and deterministic requirements specified in ISO 13623 such as hoop stress, burial depth, pressure testing and NDE during construction.

6.2 Route selection

6.2.1 Considerations

6.2.1.1 General

Add to this clause:

1. For pipelines on land, location classes shall be identified along the pipeline route for pipelines transporting category D and E fluids.
2. Location classes shall be in accordance with Annex B of ISO 13623, unless another classification method is specified in applicable regulations.
3. Layout and separation requirements between pipelines (including pig traps) and other facilities within a plant fence or on an offshore platform shall follow DEP 80.00.10.11-Gen. and DEP 80.00.10.12-Gen.

Layout and separation requirements are normally determined as part of the plant or platform layout study and safety case. Optimisation of the layout is a primary means of both preventing incidents and preventing incipient incidents from escalating in plants and at offshore platforms.

6.2.1.2 Public safety

Replace second paragraph of this clause with:

1. A documented quantitative risk assessment (QRA) shall be carried for pipelines:
 - a. on land;
 - b. all location classes except location class 1, as defined in Annex B, Table B.1 of ISO 13623;
 - c. conveying fluid category B, C, D or E as defined in Table 1 of ISO 13623.
2. The final QRA shall confirm that risks are ALARP for the selected design and proximity distances and be subject to approval by the Principal.
3. Risk levels may be reduced by using higher wall thickness, re-routing, providing additional protection to the pipeline, application of facilities to minimise any released fluids, and controlled methods of operating, maintenance and inspection.

Pipelines with a wall thickness less than 10 mm (3/8 in) are particularly susceptible to penetration, even by small mechanical excavators. External interference by third parties is a major cause of pipeline failures.

4. General requirements for the planning, execution and documentation of safety evaluations are provided in Annex A.

For the purpose of initial routing of pipelines on land, Annex C5 provides guidance for estimating the minimum distance between the pipeline and normally occupied buildings, depending on the type of the fluid, the pipeline diameter and its maximum allowable operating pressure. This methodology is intended for initial planning/guidance purposes only and does not replace the requirement for a QRA. The QRA can demonstrate the acceptability of reduced minimum distances, adopting a risk based approach.

6.2.1.3 Environment

Add to this clause:

1. An environmental impact assessment (EIA) shall be carried out for all pipelines or, if more appropriate, groups of pipelines.

An EIA may be carried out as part of the overall project EIA. An EIA is generally not required for deep water flowlines that tie-back to existing deepwater facilities.

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

2. An EIA should consider the interaction between the pipeline and the environment during each stage of the pipeline life cycle as the characteristics of the environment may affect the pipeline design, construction method, reinstatement techniques, and operational philosophy and requirements.
3. National requirements for the protection of the environment shall be applied where they are more stringent than the requirements specified in this DEP.

6.2.1.7 Construction, testing, operation and maintenance

Add to this clause:

1. In determining the onshore pipeline route and selection of landfall locations, consideration shall be given to different crossing methods. In determining the offshore pipeline route, consideration shall also be given to the installation method.

2. Other aspects that require consideration during route selection are:

- a. for pipelines on land:

- i. all pipelines should have a permanent right of way with a preferred minimum width of:

- 1). 4 m (13 ft) for DN 150 (NPS 6) and below;
- 2). 6 m (20 ft) for DN 200 (NPS 8) to DN 300 (NPS 12);
- 3). 8 m (26 ft) for DN 350 to DN 500 (NPS 14 to 20);
- 4). 10 m (33 ft) for DN 600 (NPS 24) and above.

- ii. the pipeline route should be centred on the permanent right of way;

In some cases, particularly for larger diameter pipelines, the pipeline may be shifted to one side of the permanent right of way to provide space for future pipelines and/or a maintenance and inspection access road along the pipeline.

- iii. the elastic radius of curvature of the pipeline along its route shall not be less than 500xDN;
- iv. Cold or Hot bends should be used when the elastic radius of curvature of the pipeline along its route is less than 500xDN (see (10.6.2));
- v. when several pipelines are installed in the same trench, the separation between adjacent pipelines should be 0.5 m (20 in) minimum;