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"“जानने का अधिकार, जीने का अधिकार”
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

"पुराने को छोड़ नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”


“ज्ञान से एक नये भारत का निर्माण”
Satyanarayan Gangaram Pitroda
“Invent a New India Using Knowledge”

“ज्ञान एक ऐसा खजाना है जो कभी चुरा या नहीं जा सकता है”
Bhartrhari—Nitisatakam
“Knowledge is such a treasure which cannot be stolen”
Indian Standard

DESIGN AND INSTALLATION OF NATURAL GAS PIPELINES — CODE OF PRACTICE

PART 1 LAYING OF PIPELINES

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

May 2006
FOREWORD

This Indian Standard (Part 1) was adopted by the Bureau of Indian Standards, after the draft finalized by the Structural Engineering and Structural Sections Sectional Committee had been approved by the Civil Engineering Division Council.

Natural gas has been utilized in the country for many years. With increased exploration efforts and enhanced production, utilization of natural gas has also increased. Natural gas is considered to be much more environment friendly and is therefore being preferred as an alternate fuel. Natural gas is envisaged to be an emerging fuel in the country and is slated to cater to a major portion of the country’s energy requirement. The utilization of natural gas is however largely dependent on an efficient transmission and distribution network through pipeline systems; connecting gas sources, gas production plants, process plants, storage facilities, to the users/consumers spread across long distances. Towards this objective of its efficient usage, there is a focus on development of pipeline infrastructure through extensive pipeline networks for transmission and distribution of natural gas in the country.

Considering the above, a need was felt to develop a standard that prescribes the requirements necessary for the safe design and installation of such pipelines and its testing and commissioning. The recommended actions set out in the standard are intended to protect the public life as well as the environment from possible hazards in transportation of the gas. The recommendations are applicable to conditions that are normally encountered and additional design considerations may be necessary where unusual conditions are encountered. This standard is published in three parts. The other parts in this series are:

- Part 2  Laying of pipelines in crossings
- Part 3  Pre-commissioning and commissioning of pipelines

The standards keep in view the practices in the country in the field and the safety considerations in following guidelines of the Oil Industry Safety Directorate:

- OISD-STD-141  Design and construction requirement of cross country hydrocarbon pipelines
- OISD-STD-118  Layout of oil and gas installations
- OISD-STD-117  Fire protection facilities for petroleum depots, terminal and pipeline installations

Assistance have also been derived from the following International Standards:

- ISO 13623  Petroleum and natural gas industries — Pipeline transportation systems
- ASME B 31.8  Gas transmission and distribution piping systems
- API RP 1102  Steel pipelines crossings railroads and highways
- API 1104  Welding of pipelines and related facilities
Indian Standard

DESIGN AND INSTALLATION OF NATURAL GAS PIPELINES — CODE OF PRACTICE

PART 1 LAYING OF PIPELINES

1 SCOPE

The standard (Part 1) specifies the requirements and gives recommendations for the design, materials, construction and testing of pipelines made of steel and used in the transportation of natural gas and re-gasified liquid natural gas (RLNG). Specific requirements for laying of pipelines in crossings (road, railway, watercourses, other pipelines, etc) are covered in IS 15663 (Part 2). The requirements for pre-commissioning and commissioning of pipelines are covered in IS 15663 (Part 3).

The provisions of the standard apply to pipelines on land including pipelines up to and including isolation valves of compressor station, process plant, liquid natural gas terminals, etc and within the boundaries of such facilities like sectionalizing valve stations, intermediate pigging stations, etc; that form part of the pipeline system connecting gathering stations or process plants to dispatch stations. The provisions in the standard do not include the requirements of operation and maintenance of such pipelines. The scope of the standard is also illustrated in Fig. 1 in Annex A.

The standard is not applicable for pipelines constructed from materials other than steel and for pipelines that form part of distribution systems.

2 REFERENCES

The standards given below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publications, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 269 : 1989</td>
<td>Specification for ordinary portland cement, 33 grade (fourth revision)</td>
</tr>
<tr>
<td>IS 383 : 1974</td>
<td>Specification for coarse and fine aggregates from natural sources for concrete (second revision)</td>
</tr>
<tr>
<td>IS 456 : 2000</td>
<td>Code of practice for plain and reinforced concrete (fourth revision)</td>
</tr>
<tr>
<td>IS 1489 : 1989</td>
<td>Specification for portland pozzolana cement:</td>
</tr>
<tr>
<td>(Part 1) : 1989</td>
<td>Flyash based (third revision)</td>
</tr>
<tr>
<td>(Part 2) : 1989</td>
<td>Calcined clay based (third revision)</td>
</tr>
<tr>
<td>IS 1498 : 1970</td>
<td>Classification and identification of soils for general engineering purposes (first revision)</td>
</tr>
<tr>
<td>IS 1978 : 1982</td>
<td>Specification for line pipe (second revision)</td>
</tr>
<tr>
<td>IS 8062 : 2006</td>
<td>Code of practice for cathodic protection of buried pipelines/structure for transportation of oil, natural gas and liquids</td>
</tr>
<tr>
<td>IS 8112 : 1989</td>
<td>Specification for 43 grade ordinary portland cement (first revision)</td>
</tr>
<tr>
<td>IS 15659</td>
<td>Specification for petroleum and natural gas industries — External coating for buried or submerged pipelines used in pipeline transportation of gas and liquid hydrocarbons:</td>
</tr>
<tr>
<td>(Part 1) : 2006</td>
<td>Polyolefin coatings (3-layer PE and 3-layer PP)</td>
</tr>
<tr>
<td>(Part 2) : 2006</td>
<td>Fusion bonded epoxy coatings</td>
</tr>
<tr>
<td>IS 15663 : 2006</td>
<td>Design and installation of natural gas pipelines — Code of practice:</td>
</tr>
<tr>
<td>(Part 2) : 2006</td>
<td>Laying of pipelines in crossing</td>
</tr>
<tr>
<td>(Part 3) : 2006</td>
<td>Pre-commissioning and commissioning of pipelines</td>
</tr>
<tr>
<td>API 1104 : 2005</td>
<td>Welding of pipelines and related facilities</td>
</tr>
<tr>
<td>API RP 5L1 : 2002</td>
<td>Recommended practice for railroad transportation of line pipe</td>
</tr>
<tr>
<td>API RP 5LW : 1996</td>
<td>Recommended practice for transportation of line pipe on barges and marine vessels</td>
</tr>
<tr>
<td>API 6D : 2002</td>
<td>Specification for pipeline valves</td>
</tr>
<tr>
<td>ASME B 16.9 : 2001</td>
<td>Factory made wrought steel butt welding fittings</td>
</tr>
</tbody>
</table>
3 TERMINOLOGY

For the purpose of this standard the following definitions shall apply.

3.1 Design Factor — Is a constant considered in determining internal design pressure and is based on the location class of a pipeline.

3.2 Design Pressure/Internal Design Pressure — The maximum internal pressure for which the pipeline or its section is designed in accordance with the requirements of this standard.

3.3 Design Temperature

3.3.1 Design Temperature, Maximum — The highest possible metal temperature during installation and operation.

3.3.2 Design Temperature, Minimum — The lowest possible metal temperature during installation and operation.

3.4 Despatch Station — Stations where gas is received and dispatched to pipeline system or consumer.

3.5 Gas Gathering Station — Station where gas is gathered from various wells/sources.

3.6 Hydrostatic Test Pressure — The pressure at which hydrostatic test is conducted on a section of a pipeline.

3.7 Intermediate Pigging Station — An intermediate station used for launching and receiving of pigs for cleaning and health monitoring of pipeline system.

3.8 Location Class — The geographical area along the pipeline classified according to criteria based on population density and human activity (present and anticipated for future).

3.9 Maximum Allowable Operating Pressure (MAOP) — The maximum pressure at which the pipeline system is allowed to be operated. The MAOP is less than or equal to the design pressure.

3.10 Nominal Outside Diameter — Is the as produced or as specified actual outside diameter of the pipe.

3.11 Nominal Pipe Size (NPS)/Nominal Size — Is the dimensionless designator of a pipe and is the standard pipe size when followed by a number.

3.12 Nominal Wall Thickness — Is the wall thickness computed by or used in design calculation.

3.13 Operating Pressure — Is the pressure at which a pipeline is operated during normal operating cycle, not exceeding the design pressure.

3.14 Pipeline — Those facilities through which natural gas is transported, including pipe, pig traps, components and appurtenances up to and including isolation valves.

3.15 Pipeline Design Life — The period of time considered for the purpose of verifying that a replaceable or permanent component is suitable for the anticipated period of service.

3.16 Pipeline System — Trunk pipelines up to and including isolation valves (of compressor stations, process plants, LNG terminals, etc), pressure control valves, flow control stations, metering, supervisory control and data acquisition system (SCADA), safety systems, corrosion protection systems, sectionalizing valves, intermediate pigging stations, tap offs, receiving/despatch terminals and any other equipment, facility or building used in the transportation of natural gas.

3.17 Processing Plant — Location where gas is processed involving a change in its composition.

3.18 Regassified Liquid Natural Gas — The natural gas obtained after gasification of liquid natural gas.

3.19 Right-of-Use/Right-of-Way — The corridor of land within which the pipeline operator has the right to conduct activities in accordance with the agreement with the land owner.

3.20 Sectionalizing Valve Station — A valve station in a main pipeline system installed to isolate a particular pipe section whenever needed.

3.21 Specified Minimum Yield Strength (SMYS) — Is the minimum yield strength required by the specification or standard under which the material is purchased.

4 PUBLIC SAFETY, PROTECTION OF ENVIRONMENT AND STATUTORY REQUIREMENTS

The pipeline should meet the requirements of safety, health and environment in accordance with applicable statutory/regulatory requirements. The effect of the pipeline on the environment along its route shall be taken into consideration while planning, in designing, during construction and for intended operation. Appropriate authorizations shall be obtained from the
landowners and appropriate authorities as applicable, including other utilities being affected by the pipeline system. For safety in construction the applicable guidelines of Oil Industry Safety Directorate shall be complied with. Applicable statutory/regulatory requirements have been listed in Annex B for guidance.

5 PIPELINE DESIGN

5.1 General

5.1.1 The pipelines shall be designed in a manner that ensures adequate public safety under all conditions likely to be encountered and to withstand all installation, testing and operating conditions/loads. All necessary calculations shall be carried out to verify structural integrity and stability of the pipeline for combined effect of pressure, temperature, bending, soil-pipe interaction, external loads and other environmental parameters as applicable. Such calculations shall include but not be limited to the following:

a) Buoyancy control and stability analysis for pipeline section to be installed in areas subjected to flooding/submergence,
b) Crossing analysis of rivers by trenchless techniques, wherever soil data is favourable for such operation,
c) Pipeline expansion/contraction and its effect on station piping (above ground), and
d) Evaluation of potential for earthquake occurrence along pipeline route and carrying out requisite seismic analysis to ensure safety and integrity of the pipeline system.

5.1.2 A significant factor contributing to the failure of a pipeline is the damage caused to the pipeline by activities along the route of the pipeline associated with human dwellings and commercial/industrial installations. Pipelines and its associated facilities are designed to meet the requirements of Location Class, based on the degree of exposure of the pipeline to such damage. The design of the pipeline is related to the Location class by an appropriate design factor (see 5.3).

5.1.3 The pipelines shall be normally designed for an assumed economic design life of 30 years. The pipelines are designed for the following operating temperature limits:

a) above ground: 65°C maximum and –28°C minimum
b) below ground: 60°C maximum and –28°C minimum.

5.2 Survey

5.2.1 Route Selection

Route selection shall take into account the design, construction, operation and maintenance of the pipeline taking the following into consideration:

a) safety of public and personnel working on or near the pipeline;
b) protection of environment, other properties and facilities; including electrical interferences;
c) third party activities;
d) geotechnical and hydrological conditions;
e) requirements of construction, operation and maintenance of the pipeline;
f) future explorations and developmental plans;
g) existance of archeological/historical monuments, reserved forests, national parks, etc.

In order to ensure adequate safety to public, wherever practicable, pipelines should avoid built-up areas or areas having human activities. The applicable safety requirements as given in this standard and those of other statutory requirements shall be followed.

5.2.2 An assessment of the environmental impact of the pipeline shall also be made, giving consideration but not limited to the following requirements:

a) temporary works to be undertaken during construction and repair,
b) effect of the pipeline, and
c) effects of any possible loss of gas.

5.2.3 The impact on other facilities along the pipeline route shall also be determined and evaluated with the owners of such facilities. Any third party activity along the route shall be identified and evaluated in consultation with the parties concerned. Adverse geotechnical and hydrological conditions shall also be identified along with measures to address the same. The route selected shall also permit access and the space required for carrying out construction, testing, operation and maintenance of the pipeline. Route and soil surveys shall be carried out to identify and locate the relevant geographical, geological, and environmental features and other facilities such as other pipelines, cables, obstructions and crossings that could have an impact on the pipeline.

5.2.4 Determination of Location Class

When survey is performed for gas pipelines, the class locations based on population density index shall be recorded along with chainages at change points of each class location. Population density index along the pipeline route shall be determined in accordance with the procedure given in Annex C.
5.3 Design Factor and Location Classes

Pipelines shall be designed using the design factors for each designated location class and the type of facility as given in Table 1.

5.4 Loads

5.4.1 General

The pipeline shall be designed to withstand all loads that are likely to be encountered in its installation, testing, operation and maintenance.

For the purpose of design, loads shall be classified as:

a) operational loads,

b) environmental loads,

c) construction loads, and

d) accidental loads.

5.4.1.1 Operational loads

Loads from the intended use of the pipeline shall be classified as operational loads. These shall include the loads from the self weight of the pipeline, loads due to internal pressure and temperature of gas being transported, loads from soil cover, external hydrostatic pressure, reaction forces at supports from operating loads, surge, etc.

5.4.1.2 Environmental loads

Loads arising from the environment shall be classified as environmental, unless these are to be considered as operational or as accidental. Loads from winds, earthquake, snow, traffic, etc, are considered as environmental loads.

5.4.1.3 Construction loads

Loads arising from the installation and pressure testing of the pipeline system shall be considered as construction loads. These will include loads arising from transportation, handling, storage, construction and pressure testing.

5.4.1.4 Accidental loads

In addition possible loads from fire, explosion, falling objects, landslides, equipments, etc, that are possible but the occurrence of which has low probability shall also be taken into consideration as accidental loads.

5.4.1.5 Combination of loads

While designing the pipeline the most unfavourable load combination from operational, environmental, construction and accidental loads, that is, likely to occur simultaneously shall be considered.

5.4.2 Internal Design Pressure

The internal design pressure at any point in the pipeline system shall be equal to or greater than the maximum allowable operating pressure (MAOP).

The internal design pressure shall be determined from the following:

\[ P = \left[ \frac{2St}{D} \right] F.E.T \]

where

- \( D \) = specified outside diameter of the pipe, in mm;
- \( E \) = longitudinal joint factor, which for electric resistance welded (ERW), longitudinal seam submerged arc welded (LSAW), helical seam submerged arc welded (HSAW) and seamless types of pipes, manufactured in accordance with IS 1978 shall be considered as 1;
- \( F \) = design factor obtained from Table 1;
- \( T \) = temperature derating factor, which for the temperature conditions defined in this standard (see 5.1.3) shall be considered as 1;
- \( S \) = specified minimum yield strength (SMYS) in N/mm² of pipe material;

Table 1 Design Factor for Pipeline Construction

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Facility</th>
<th>Location Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Class 1</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>i)</td>
<td>Main pipelines</td>
<td>0.72</td>
</tr>
<tr>
<td>ii)</td>
<td>Station piping</td>
<td>0.5</td>
</tr>
<tr>
<td>iii)</td>
<td>Watercourse (River/stream) crossing, trenchless or open cut</td>
<td>0.6</td>
</tr>
<tr>
<td>iv)</td>
<td>Cased/uncased crossings or parallel encroachments on right-of-use of hard surfaced roads, public streets and highways</td>
<td>0.6</td>
</tr>
<tr>
<td>v)</td>
<td>Rail crossings</td>
<td>0.5</td>
</tr>
<tr>
<td>vi)</td>
<td>On bridges</td>
<td>0.4</td>
</tr>
</tbody>
</table>
\( t = \) nominal wall thickness, in mm; and
\( P = \) internal design pressure, in N/mm².

### 5.5 Strength Requirements

#### 5.5.1 Determination of Stresses

##### 5.5.1.1 Hoop stress due to gas pressure
The hoop stress due to gas pressure shall be calculated from the following:

\[
S_{hp} = \frac{P \cdot (D - 2t_{Min})}{2 \cdot t_{Min}}
\]

where

- \( S_{hp} \) = circumferential hoop stress due to gas,
- \( P \) = internal design pressure,
- \( D \) = specified outside diameter, and
- \( t_{Min} \) = specified minimum wall thickness.

**NOTE** — The specified minimum wall thickness is the nominal wall thickness less the allowance for corrosion.

##### 5.5.1.2 Other stresses
The longitudinal, shear, bending, torsional and other stresses shall be calculated taking into account the stresses from all relevant loads as mentioned in 5.4. The stress analysis shall be carried out in accordance with the appropriate provisions in ASME B 31.8. For terminal pipe work, flexibility stress analysis shall be carried out in accordance with 5.5.1.2.1.

##### 5.5.1.2.1 Flexibility stress analysis
While designing the pipeline due consideration shall be given to the prevention of excessive stresses due to thermal expansion or contraction by providing adequate flexibility in the pipeline system. It shall be ensured that such flexibility consideration does not cause excessive stresses or loads at the pipe joints, at connections or at anchorage points. In designing for flexibility, the pipeline shall be treated as a whole and due consideration given to restraints in the pipeline system. Flexibility shall be provided by means of bends, loops, offsets, use of expansion joints, use of couplings, etc. Wherever required, the adequacy of flexibility provided in the pipeline shall be established through appropriate design calculations. The flexibility requirements specified in ASME B 31.8 shall also apply.

#### 5.5.2 Strength Criteria

##### 5.5.2.1 General
Pipelines shall be designed against failures in yielding, fatigue, ovality and fracture toughness.

##### 5.5.2.2 Yielding
The maximum hoop stress due to gas pressure shall not exceed

\[
S_{hp} < F.E.S
\]

where

- \( S \) = specified minimum yield strength (SMYS),
- \( E \) = longitudinal joint factor as defined in 5.4.2, and
- \( F \) = design factor obtained from Table 1.

##### 5.5.2.3 Fatigue
Fatigue analyses shall be carried out on pipeline sections that may be subject to fatigue from cyclic loads in order to:

a) Demonstrate that initiation of cracking will not occur; or
b) Define requirements for inspection for fatigue.

Fatigue analyses shall include a prediction of range of load cycles into nominal stress or strain range. The effect of mean stress, internal service, external environment, plastic prestrain and number of loading cycles during lifetime shall be accounted for when determining fatigue resistance.

The selection of safety factors shall take into account the inherent inaccuracy of fatigue-resistance predictions and access for inspection for fatigue damage. It may be necessary to monitor the parameters causing fatigue and to control possible fatigue damage control accordingly.

##### 5.5.2.4 Ovality
Ovality that can cause buckling or interference with pigging operations, shall be avoided.

##### 5.5.2.5 Fracture toughness
Fracture toughness requirements shall be met in the material being used in the pipeline and by selecting appropriate materials that satisfy the requirements of fatigue toughness stipulated in ASME B 31.8.

#### 5.6 Stability
Pipelines shall be designed to prevent horizontal and vertical movement, or shall be designed with sufficient flexibility to allow movements within the strength criteria being fulfilled. The following shall be considered for stability:

a) wind loads;
b) axial compressive forces at bends and lateral forces at branch connections;
c) lateral deflection due to axial compression loads in the pipelines;

d) exposure due to erosion;

e) geotechnical conditions including soil instability due to seismic activity, ground water level, etc;

f) construction methods; and
g) trenching and/or backfilling.

5.7 Pipeline Spanning

Spans in pipelines shall ensure compliance with the strength requirements in 5.5. The following shall also be taken into consideration:

a) support conditions,
b) interaction with adjacent spans,
c) possible vibrations due to wind,
d) axial forces in the pipelines,
e) soil properties and soil erosion, and

f) effects from other activities.

5.8 Additional Requirements

5.8.1 Protection of the pipelines from the following shall be considered:

a) effects of pipeline damage on safety and environment;

b) effects of interference from other activities; and
c) requirements of public safety and protection of the environment.

NOTE — Activities to be considered for this purpose shall include other land users, traffic, cultivation, drainage installations, building construction and work on roads, railways and waterways.

5.8.1.1 The requirements for protection of pipelines shall form a part of the safety evaluation in 4, where required.

5.8.1.2 Markers shall be erected at road, rail and canal crossings and elsewhere, to enable other users of the area to identify the location of the pipelines.

NOTE — Protection of pipelines shall include increased wall thickness, cover, mechanical protection, controlling access to pipeline route, markers, or a combination of these measures.

5.8.2 Pipeline Cover

The pipeline shall be buried normally at a depth of 1.0 meter except at watercourse/rail/road crossings where minimum cover shall be as given in Table 2. Increased wall thickness and cover shall be provided at critical locations and crossings.

5.8.2.1 Additional soil cover other than that specified above shall be provided at locations indicated by statutory/local authorities or in areas likely to have an

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Locations</th>
<th>Minimum Cover m</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>i)</td>
<td>Areas of agricultural, horticultural activity and of limited or no human activity</td>
<td>1.0</td>
</tr>
<tr>
<td>ii)</td>
<td>Industrial, commercial and residential area</td>
<td>1.0</td>
</tr>
<tr>
<td>iii)</td>
<td>Rocky terrain</td>
<td>1.0</td>
</tr>
<tr>
<td>iv)</td>
<td>Drainage, ditches at roads/railway crossing</td>
<td>1.2</td>
</tr>
<tr>
<td>v)</td>
<td>Minor river crossings/canal/drain/nala/ditches</td>
<td>1.5</td>
</tr>
<tr>
<td>vi)</td>
<td>Major river crossings (below scour level)</td>
<td>2.5</td>
</tr>
<tr>
<td>vii)</td>
<td>River with rocky bed (below scour level)</td>
<td>1.5</td>
</tr>
<tr>
<td>viii)</td>
<td>Area under influence of tides</td>
<td>1.5</td>
</tr>
<tr>
<td>ix)</td>
<td>Cased/Uncased road crossing</td>
<td>1.2</td>
</tr>
<tr>
<td>x)</td>
<td>Cased railway crossing</td>
<td>1.7</td>
</tr>
</tbody>
</table>

NOTES

1. The depth of cover shall be measured from the top of the pipe coating to the top of the undisturbed surface of soil or the top of graded working strip, whichever is lower. The fill material in the working strip shall not be considered in the depth of cover.

2. The cover shall be measured from the top of road or top of rail, as the case may be.

3. For river/watercourses that are prone to scour and erosion, adequate safe cover shall be provided below the predicted scour profile expected during the life time of the pipeline.

4. When scour level is not known, an additional cover of 1 m shall be provided from the existing bed of the river/watercourse.

5. The minimum cover requirements shall be applicable for all Location Classes.

6. Whenever the above provisions of cover cannot be provided due to site constraints, additional protection in form of casings, bridging, etc, shall be provided.
increased risk of impact damage or third party interference.

5.8.3  **Pipe Wall Thickness**

Pipe wall thickness calculations shall be carried out in compliance with this standard and a corrosion allowance as per the requirements of the owner of the pipeline shall be added to the calculated thickness. Pipe thickness shall be checked and revised as required to minimize the number of field hydrostatic testing sections, considering combined testing of pipes in different class locations. In addition the selected thickness shall also be checked to ensure that the diameter to thickness (D/t) ratio does not exceed 70 in order to avoid damage to pipe during handling and transportation, unless the pipes are loaded/transported in accordance with API RP 5L1 or API RP 5LW; or the pipeline shall be hydrostatically tested for at least 2 h at a minimum pressure of 1.25 times the design pressure for pipelines installed in Location Class 1 areas and for a minimum pressure of 1.5 times the design pressure if the pipelines are installed in Location Class 2, 3, or 4 areas.

5.8.4  **Clearance Between Pipelines/Mains and Other Underground Structures**

5.8.4.1  A clearance of at least 150 mm shall be provided between a buried pipeline and other underground structure not used in conjunction with the pipeline. Wherever such clearance cannot be provided, adequate precautions to protect the pipeline by means of casing, bridging, or insulating material shall be ensured.

5.8.4.2  In laying parallel pipelines in the same trench, the minimum clear distance between the pipelines shall be 500 mm.

5.8.4.3  The location of a new underground pipeline, when running parallel to an existing underground pipeline shall be at a minimum clear distance of 5 m. Wherever such clearances cannot be provided, adequate precautions to protect the pipelines by means of casing or insulating material shall be ensured.

5.8.5  **Additional Design Considerations for Piping for Dispatch Stations, Tap-Off Stations and Receiving Stations**

5.8.5.1  All piping and equipment shall be designed in accordance with the provisions of this standard. All piping materials shall be as in 6.2. Utility piping to be provided shall be designed in accordance with the provisions in 5. Design shall provide consideration for all loadings like weight, temperature, etc, that may significantly induce stresses in the pipe material in addition to fluid pressure.

5.8.5.2  **Piping flexibility/stress analysis**

All piping shall be designed for thermal expansion under start up, operating and shut down conditions without over stressing the piping, valves or other equipment. Provisions for expansion shall normally be made with bends and offsets. All piping shall be adequately supported, guided or anchored so as to prevent undue vibration, deflection or loads on connected equipments. Equipments/valves requiring periodical maintenance shall be supported in such a way that the valves and equipment can be removed with minimum temporary pipe supports.

5.8.5.3  **Piping layout**

Wherever possible, piping shall be located above the ground. Piping shall be designed considering skin temperature of piping material under empty conditions as 65°C or the design temperature of pipeline, whichever is higher. Wherever felt necessary, stress analysis shall be carried out in order to determine the allowable pipe movement and support requirements. Buried piping inside the terminal area shall have a minimum depth of cover of 1.2 m. Where buried pipes come out of the ground, the underground coating on the pipe will continue for a length of at least 500 mm above ground. Platforms and crossovers shall be provided for ease of operation and maintenance.

5.9  **Hydrostatic Pressure Test Requirements**

Pipelines shall be hydrostatically tested in place after installation and before putting into operation for demonstrating their strength and leak tightness. Prefabricated sections and tie-in sections may be pre-tested before their installation.

5.9.1  **Test Medium**

Pressure tests shall be conducted with water (if required with inhibited water), except when ambient temperature conditions prevent testing with water. Pneumatic tests may be carried out with air or a non-toxic gas in such instances, for a limited section of the pipeline employing adequate safety, with test conditions as agreed to between the owner and the construction agency.

5.9.2  **Test Pressure and Test Duration**

5.9.2.1  The minimum hydrostatic pressure in any section shall be as given in Table 3. The maximum hydrostatic pressure shall not however exceed the pressure required to produce a hoop stress equal to 95 percent of SMYS of the pipe material based on minimum wall thickness in the test section. The test duration shall be a minimum 24 h. Mainline valves shall be installed after successful completion of hydrostatic pressure testing. All sections that have been previously
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hydrostatically tested, namely, road/rail and river crossings, may be retested along with the complete mainline sections.

Table 3 Test Pressure Requirements
(Clause 5.9.2.1)

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Location Class</th>
<th>Pressure Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>1</td>
<td>1.25 \times \text{Design Pressure}</td>
</tr>
<tr>
<td>(2)</td>
<td>2</td>
<td>1.25 \times \text{Design Pressure}</td>
</tr>
<tr>
<td>(3)</td>
<td>3</td>
<td>1.40 \times \text{Design Pressure}</td>
</tr>
<tr>
<td>(4)</td>
<td>4</td>
<td>1.40 \times \text{Design Pressure}</td>
</tr>
</tbody>
</table>

5.9.2.2 Hydrostatic pressure testing of terminals shall be carried out separately. Pneumatic test at 5 kg/cm² shall be carried out prior to hydro test of terminals for a minimum period of 30 min for the purpose of detecting any leakages in gaskets/joints. Dispatch/Receipt terminals as well as other intermediate facilities shall be tested at 1.4 times the design pressure. The hydrostatic pressure test duration shall be for a minimum of 4 h.

5.9.3 Acceptance Criteria

Pressure variations during testing shall be acceptable, if caused by factors other than leakage, like temperature variations.

 Pipelines not meeting the requirements shall be repaired and retested in accordance with the requirements of this standard.

5.10 Design for Pigging

The pipelines shall be designed to meet the requirements for pigging considering the following:

a) location of the permanent pig traps or connections for temporary pig traps;
b) access to the pig traps;
c) handling facilities;
d) isolation requirements necessary for pig launching and receiving;
e) venting and draining requirements for pre-commissioning and operation;
f) direction of pigging including bi-directional pigging;
g) minimum permissible bend radius and the distances between bends/fitting;
h) maximum permissible changes in diameter and tapering requirements at internal diameter changes;
i) fittings/branch connections and compatibility of line pipe material;
j) internal coatings; and
k) pig signalers.

The safety of access routes and adjacent facilities shall be considered when determining the orientation of pig traps.

5.10.1 Scraper Traps/Scraper Barrels

Scraper traps/scraper barrels shall be provided at the dispatch, and receiving terminals. The scraper traps shall be capable of handling intelligent pigs and other cleaning pigs. All anticipated pigging operations, including possible internal inspection shall be considered when determining the dimensions of traps. The launching and receiving barrels and its closures shall be designed in accordance with the requirements of this standard. Adequate arrangements for launching, retraction, handling and lifting of cleaning and instrumented pigs shall be provided at the scraper station. These stations shall be provided with access road from the nearest metal road. Corrosion resistant coating shall be provided on the pipeline up to a minimum length of 500 mm after it comes above ground/before it gets buried underground at terminal and scraper stations. The traps shall be pressure tested in accordance with 5.9.

The diameter of traps of the launcher shall be suitable for uni-directional/bi-directional traps. Centre-line elevation of scraper trap shall be at suitable height from grade level. Suitable arrangements shall be provided for handling and lifting of pigs. Traps shall be accessible by walkway/road for movement of equipment, pigs, etc.

5.10.1.1 The piping system at the terminals and intermediate stations shall be designed to have sufficient flexibility to prevent pressure and thermal expansion or contraction from causing excessive stresses on the connected equipment. Installation of anchor block in the underground pipeline shall not be permitted. If required adequate length of trench in approaches to stations shall be provided with a select backfill to ensure flexibility.

5.10.2 Pig Signallers

At least two pig signallers, one on the trap and one on the pipe (above ground) shall be provided. Pig signaller shall be bi-directional type with trigger mechanism, suitable for maintenance with pipeline under operating pressure. Operational access shall be provided for all pig signallers installed on buried pipeline sections within the boundaries of the station.

5.11 Section Isolation Valves and Valve Stations

5.11.1 Section isolation valve stations shall be provided for isolating sections of pipeline in order to:

a) Limit the hazard and damage from accidental discharge from pipeline system; and
b) Facilitate maintenance of pipeline system.
5.11.1.1 Section isolation valves shall be installed at
beginning and end of a pipeline and where required
for operation and maintenance and control of
emergencies. Factors such as topography of the
location, ease of operation and maintenance including
requirements for pressure relief, security, proximity
to occupied buildings shall be taken into consideration
in deciding the location of the valves. The maximum
distance between the location of any two section
isolation valve stations shall be as given below, based
on the location class and taking into consideration
factors like the terrain features, requirement of safety
and operation, etc.

<table>
<thead>
<tr>
<th>Location Class</th>
<th>Maximum Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

The valve stations shall be located at a readily
accessible location such as near roads and shall be
provided with an access road from the nearest all
weather metalled road. The facilities within valve
station shall be secured by providing a suitable
enclosure with gate. The location of valve station shall
be clear of overhead power lines. Pipeline to be located
within the section isolation valve station limits shall
be of wall thickness appropriate for the applicable
Location Class, but in no case shall be less than that
applicable for Location Class 3. The provisions of
remote operated feature shall be as per the operation
and control philosophy to be adopted for the project.
At locations where valve stations are combined with
compressor/repeater stations, the requirements of safe
distance and statutory clearance, as applicable, shall
be followed.

5.11.2 Valve shall be installed buried and provided
with a stem extension in such a way that the centre of
actuator is at approximately 1.0 m above the finished
ground level. Section isolation valve on the main
pipeline shall be ball valves of full bore type, to allow
smooth passage of cleaning and intelligent pigs.
Pipeline sectionalizing valve may be either gas actuated
or manually/electrically/pneumatically/hydraulically
operated and with butt-welding ends. Valve surface
shall be provided with corrosion protection coating.
Valve body vent and drain lines shall be extended and
terminated above ground.

6 MATERIALS

6.1 General

Materials for use in the pipeline system shall:

a) have the mechanical properties necessary
to comply with the design requirements
specified in 5,
b) have necessary properties to comply with
the requirements for corrosion control
specified in 6.8.1.2, and
c) be suitable for the intended fabrication and/or
construction methods.

6.2 Line Pipes

Line pipe shall conform to IS 1978. The material for
station piping shall also conform to IS 1978 or equivalent.

6.3 Bends

Bends may be made from pipe material complying with
the mechanical properties of the line pipe. Bends shall
satisfy the requirements of minimum wall thickness
of the adjacent piping. The minimum radius of cold
field bends shall be as given below:

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Minimum Radius of Bend</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS 12 and below</td>
<td>21 D</td>
</tr>
<tr>
<td>NPS 14 and up to</td>
<td>30 D</td>
</tr>
<tr>
<td>including NPS 18</td>
<td></td>
</tr>
<tr>
<td>NPS 20 and above</td>
<td>40 D</td>
</tr>
</tbody>
</table>

Where, D is the specified outside diameter of the pipe.

For underground pipeline not subjected to intelligent
pigging, bends of radius of 1.5 times the specified
outside diameter of pipe may be used. Long radius
bends of a minimum radius of 5D may be used for
pipelines subjected to intelligent pigging. Mitres shall
not be permitted in the field for change of direction.

6.4 Valves

6.4.1 The application of various types of valves shall
be as follows:

<table>
<thead>
<tr>
<th>Valve Type</th>
<th>Typical Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globe/Plug</td>
<td>Throttling</td>
</tr>
<tr>
<td>Ball</td>
<td>On/off, Isolation (on main line)</td>
</tr>
<tr>
<td>Check</td>
<td>Uni-directional flow</td>
</tr>
</tbody>
</table>

6.4.2 All pipeline valves shall conform to the
requirements of API 6D or equivalent. Ball valves for
main line shall have primary metal seat design. In order
to minimize potential leak sources, valves used in
mainline shall be with butt-weld ends. Flanges may be
used where frequent access or removal of equipment
is required. Valves used in buried portion shall be with
butt-weld joints only, except at the locations where hot
tapping operation is to be carried out for which, buried
flanged end valve may be provided.
6.4.2.1 Wherever underground valves are provided, these shall be provided with a stem extension in such a way that the centerline of the rim of the hand wheel on a horizontal shaft or centre of power actuator is approximately 1.0 m above the finished ground level. Valve surface shall be provided with suitable corrosion protection coating.

6.5 Branch Connections

Minimum size of any tapping from the underground pipeline shall be of 50 mm nominal bore and shall be provided with an isolation ball valve located at a minimum distance of 50 mm from the pipeline. All branch connections or side tap on the piggable lines having branch line diameter equal to or exceeding 40 percent of the main pipe diameter, shall be provided with flow tees/bar tees in order to enable smooth passage of cleaning, gauging, instrumented and other pigs. All flow tees/bar tees shall comply with the requirements of ASME B 16.9.

6.6 Insulating Joints

Insulating joints shall be provided to electrically isolate the buried pipeline from above ground pipeline. Insulating joints shall be monolithic type and shall allow smooth passage of pigs. Insulating joints shall either be installed in above ground portion of the pipeline, immediately after the buried/above ground transition at the scraper stations or in buried portion at underground pipeline.

6.7 Fittings and Flanged Connections

The fittings and flanged connections shall comply with the appropriate requirements specified in ASME B 31.8.

From the launcher/receiver to the mainline, the fittings/flange connections shall match the strength of the main line.

6.8 Coatings

All coatings shall cover the following requirements:

- a) type of the coating;
- b) thickness of the individual layers of coating and its total thickness;
- c) composition of the coating/base material;
- d) mechanical properties;
- e) temperature limitations in use;
- f) surface preparation requirements;
- g) adhesion requirements; requirements for materials, application and curing, including possible requirements for health, safety and environmental aspects; and
- h) requirements for testing and inspection, and repair procedures where relevant.

6.8.1 External Coatings

6.8.1.1 Concrete weight coating

6.8.1.1.1 Materials

33 grade Ordinary Portland Cement conforming to IS 269 or 43 grade Ordinary Portland Cement conforming to IS 8112 or Portland Pozzolana Cement conforming to IS 1489 (Part 1) or IS 1489 (Part 2) shall be used.

Aggregates shall comply with the requirements of IS 383.

Water used in concreting shall preferably be limpid, fresh and clean and shall be free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Water shall not contain salts of chlorides, sulphates and magnesium.

Reinforcement used shall consist of welded steel wire fabric manufactured in flat sheets or in rolls (ribbon mesh) and shall conform to IS 1566.

6.8.1.1.2 Coating requirements

The compressive strength of concrete shall not be less than 20 Mpa at 28 days and 13.5 Mpa at 7 days and the concrete mix shall meet the requirements of IS 456. Concrete shall be applied by casting or by using impingement method. The equipment for such purpose shall be capable of concreting with a reasonable degree of uniformity in thickness, density and strength.

6.8.1.1.3 Placing of reinforcements

Prior to placing of reinforcement, the pipe protective coating shall be carefully inspected and repaired if necessary and shall be free from foreign matters. The reinforcement shall protrude a minimum 50 mm from the finished concrete coating and shall rest on synthetic resin spacers or precast cubes. For concrete thickness up to 50 mm, the reinforcement shall be placed in a single layer in the middle. For thickness of more than 50 mm, the reinforcement shall be placed in two layers equally distributed. If application method requires more than one pass of concrete, one layer of reinforcement shall then be placed for each pass of concrete.

6.8.1.1.4 Placing of concrete

For concreting by impingement method, the placement of concrete to the specified thickness shall be in one continuous operation. Coating shall be bevelled to a slope of 2:1 and shall terminate about 50 mm from the end of anti corrosion coating.

6.8.1.1.5 Curing

Curing shall either be by moist curing or by using
curing membranes. In the case of moist curing, the pipe surface shall be kept wet during daylight hours for at least seven days after application of the concrete coating and the concrete coating shall not be allowed to dehydrate. In the case of membrane curing, the curing shall be performed by application of an approved curing membrane using sealing compounds, immediately after concrete coating. When membrane cured, the pipe shall not be transported for a period of at least four days from the date of concreting.

6.8.1.1.6 Tolerance in thickness and weight

Maximum variation in coating thickness checked at least at three points on the surface shall be 8 mm. The variation in weight shall be +5 percent–2 percent of the calculated theoretical weight. Each pipe shall be weighed in dry condition prior to shipment and after 28 days of placing of concrete. The weight shall be marked on the inside of the pipe.

6.8.1.1.7 Inspection and test

Non-destructive tests like ringing, shall be carried out for all coated pipes to detect any damages which is to be repaired/recoated as found necessary. Check shall also be done by megger or equivalent device for each coating to verify insulation between reinforcement and pipe.

6.8.1.1.8 Concrete coating of field welds

Uncoated pipe surface at field welds should be concrete coated. Method for concreting shall be same as for main line pipe.

6.8.1.1.9 Repairs in concrete coating

Repairs in concrete coating shall be permitted for the following:

a) Unavoidable damage in handling and in storage; and
b) Spalling (that is, loss of concrete of more than 25 percent of the total thickness). Damage due to spalling of an area of more than 0.1 m² and less than 0.3 m², the concrete shall be removed and repaired in accordance with an approved procedure.

6.8.1.1.10 Precautions in unloading, storing and hauling

During the operations of loading, unloading and stock-piling, the pipe sections shall be handled in such a way so as to avoid dents, cuts, cracks and other damages especially at bevelled ends or damages to concrete coating. Stacks shall consist of a limited number of layers such that the pressure from the self-weight of the pipes do not cause damage to the coating.

6.8.1.2 External corrosion prevention

The external coating shall be provided to pipelines to mitigate corrosion. The external coating provided shall satisfy the following factors:

a) provide adequate electrical resistance;
b) be effective in preventing ingress of moisture;
c) provide adequate adhesion between the pipe metal and the coating;
d) should not be susceptible to cathodic disbondment;
e) shall have adequate resistance to ageing, brittleness and cracking;
f) shall provide adequate shear resistance between the coating and other additional coating, environment or insulation;
g) shall not have detrimental effect on the pipe metal; and
h) shall not be easily damaged in handling, transportation, storage and installation of pipe.

6.8.1.2.1 Field joint coating of corrosion coating

The field joints shall be protected with a coating material, that is, compatible with the line pipe material. The coating shall be such that it can be easily applied in field conditions. The coating can be carried out with heat shrink wrap around sleeves or cold tape or any other suitable type of coating with mutual agreement between owner and construction agency after ascertaining its suitability for the purpose. The coating shall conform to the requirements of IS 15659 (Part 1) and IS 15659 (Part 2).

6.8.1.2.2 Coating for prevention of corrosion

Pipeline coating for external corrosion protection shall meet the requirements of IS 8062. Cathodic protection provided shall meet the requirements of IS 8062. All pipelines above ground level and structures shall be suitably painted to prevent atmospheric corrosion and as per environment requirement. Unless specified otherwise, the painting shall ensure protection in normal corrosive environment.

7 CONSTRUCTION

7.1 Construction Plan

A construction plan shall be prepared before commencement of construction to assist in control of the work. The plan shall contain a description of the construction; the health, safety and environment plan; and the quality requirements. The description of the construction should include methods, personnel and equipments required for the construction and working procedures. The health, safety and environment plan should describe requirements and measures for the
protection of the health and safety of the public and personnel involved in the construction and the protection of the environment. It should contain the applicable statutory and regulatory requirements, identification of hazards and measures required for their control and procedures for handling emergency situations.

All facilities, which may include existing roads and railways, rivers/canals, footpaths, pipelines, cables and buildings; that may be affected by the construction of the pipelines shall be identified prior to the beginning of the work. Temporary provisions and safety measures necessary to protect the identified facilities during construction should be established.

7.2 Preparation of Route

7.2.1 Site Inspection

Before the commencement of construction work, site inspection of the existing conditions along the working width of the pipeline route shall be undertaken after access to the route has been granted to ascertain facilities that would potentially get affected by construction activity and to obtain mutual approval of all parties/authorities concerned. The underground utilities in the pipeline route may be detected using tools like cable locators, ground penetrating radar, etc, to avoid accidental damages and safety of personnel.

7.2.2 Survey and Marking

7.2.2.1 Topographical survey shall be carried out along the pipeline route for locating the centre-line of pipeline alignment on the ground, constructing survey monuments, for field measurements, for planimetry and profiles and for the preparation of drawings and documents. Soil investigation for the purpose of visual engineering classification of soil along the pipeline route shall also be carried out. While undertaking the survey, the class location based on the population density index shall also be determined in accordance with 5.2.4. Work shall be performed by or under the supervision of a qualified land surveyor.

A preliminary survey for locating the centre-line of pipeline alignment on the ground and for identifying existing features or obstructions along the route shall be carried out. While locating the centre-line of the pipeline, archaeological sites, reserved forests, environmentally sensitive areas, mining sites and built up areas shall be avoided.

7.2.2.2 The pipeline defining trench centre-line shall be staked by placing suitably painted marker stakes at Turning Points (TPs) and at Intermediate Points (IPs) between consecutive TPs. Staking shall normally be done at intervals of 500 m along the centre-line of the pipeline. Stake markers shall be placed in the centre-line of the pipeline at distances of maximum 500 m for straight sections and at a maximum of 30 m of horizontal bends, but in no case less than at the centre of bends. Change in direction of line shall be marked on the TP marker stakes. Each stake marker shall carry a unique identification number, which shall be separate for TPs and IPs.

Permanent Bench Marks (BM) at approximately every 5 km or permanent structures on or off the Right-of-Use (ROU) shall be established and described.

The pipeline alignment shall run clear of the existing monuments, properties and structures as indicated in Pipeline Route Survey Data Sheet (Annex D).

7.2.2.3 Azimuth checks with respect to sun or polars shall be carried out at intervals of 15 to 20 km.

7.2.2.4 Alignment of crossings

As far as possible, crossings shall be made at right angles. The angles of crossing for all fences, property lines, utilities, roads, railways, canals, streams, etc, that are crossed shall be established. In addition, the true bearings of the center-line of the road, railway, watercourse (canals, streams, rivers), as well as that of the pipe centre-line shall also be determined. Turning Points (TPs) provided near crossings shall be located at least 50 m from the boundary of the crossings, on stable and firm ground.

The angles for all railway crossings shall be as close to 90° as possible, but in no case less than 85° to the centre-line of the railway.

The angle of crossings for national and state highways shall be as close to 90° as possible, but in no case less than 80° to the centre-line of the road. The angles of crossing for other roads (like seasonal roads, unpaved village roads, cart-tracks, etc) shall be as close to 90° as possible, but in no case less than 45° to the centre-line of the roads.

Major river crossings shall be established as close as possible to the locations shown on the route map. Crossings shall be located in a comparatively straight reach of the river, where the banks are stable and there is sufficient area for construction. Angle of crossing shall be as close to 90° as possible. For canals/drainage/ditch/nala/stream and other watercourses, the angle of crossing shall be as close to 90° as possible but in no case less than 60° to the centre-line of the canal/drainage ditch. As far as possible, crossings shall be located where there is minimum evidence of slumping or erosion of banks or bed.

Other utilities crossed shall be located at their centres with stakes containing station numbers in the survey.
The requirements specified in IS 15663 (Part 2) shall also apply.

7.2.2.5 Chainage and horizontal angles

Distance between intersection points staked along the pipeline route shall be measured and recorded. In addition, distance between level points shall also be measured and recorded. Chaining will be continuous in the direction of survey. The true bearing of all straights shall be observed and recorded. The nature of terrain like sandy, stony, vegetation, etc, and type of ground will also be recorded, along with the change in direction of survey.

Horizontal angles shall be measured to indicate the change in direction of alignment and specify the horizontal bend at the turning points. True bearing at the beginning, end and every 15 to 20 km shall be observed, to keep a check on errors in angular measurements.

7.2.2.6 Pipeline route profile

The continuous profile of the proposed pipeline route shall be established from the reduced levels taken at the starting point, at all Turning Points (TPs), at all Intermediate Points (IPs) staked on the ground, at all points on the pipeline route where there is a change in slope and at sufficient number of other points so as to give an accurate ground profile along the route.

For road and railway crossings, the reduced levels shall be recorded at all points along the pipeline alignment wherever there is a change in slope within the entire width of the right-of-use of the road/railway.

For river/stream/nala/canal crossings, levels shall be taken at intervals of 5 m, up to a distance of 30 m beyond the highest banks on both sides. Levels shall be taken at closer intervals, if there is a change in slope. For major water crossing sites, cross-section as above shall be observed and recorded at both banks.

All levels shall be with respect to Mean Sea Level (MSL).

7.2.2.7 Survey maps and drawings

Survey maps and drawings to appropriate scales shall contain all relevant data consistent with the survey notes and observations. The drawings shall also contain details of roads, streets, highways, structures, all types of crossings, terrain, surface vegetation and all other details that would be required for the purpose of engineering design.

7.2.2.7.1 Survey drawings shall contain the following data as a minimum requirement:

a) Pipeline route map shall show all features including, but not limited to roads and railroads, canals, streams, lakes, rivers, villages, towns, and cities that are located within a distance of 5 km from the pipeline centre-line on either side of it. For the entire region, contours shall be plotted on the route map at 20 m contour interval. For areas which are undulating, such as hilly areas, ghat regions, ravines, and other areas felt necessary, contours shall be plotted at 10 m contour interval. Additional information like cultivated areas, barren land, areas prone to flooding, rocky areas and forests including access paths/roads to right-of-use shall also be shown on the route maps;

b) Right-of-use planimetry drawings shall show all objects within 50 m on either side of the pipeline in plan;

c) In case of all rail, road, river, stream, canal and utility crossings, the cross-sectional detail and the angle of crossing shall be mentioned. In case of rail, road, river, stream and canal crossings wider than 10 m, the distances at the start and at the end of the crossing from the nearest Intermediate Point (IP) shall also be mentioned. For crossings less than 10 m wide, the distance of the centre-line of crossing from the nearest IP shall be given. For all river, stream and nala crossings, the level of water at the time of survey and the approximate surface velocity of the flowing stream shall be observed and recorded and reported in the survey drawings. Also, the general nature of the surface soil (soft/hard or normal soil or rock/boulders) at the bed and banks of the river/stream/nala shall be observed and mentioned in the drawings; and

d) Ground profile and cross-section for sloped right-of-use.

7.2.3 Soil Investigation

Soil investigation shall be carried out in order to obtain the visual engineering classification of soil along the pipeline route. Soil investigation would include boring, collection of disturbed samples from bore holes, visual engineering classification of soil along the pipeline route and submission of detailed report which shall include soil profiles along the pipeline route in addition to visual classification of the soil. Visual classification of soil shall be in accordance with IS 1498.

Boreholes for soil samples shall preferably be made at intervals of 500 m along the pipeline route, at all intermediate points where there is a change in the type of soil and at any other place as necessary. For canal, stream and river crossings, boreholes shall be made one on either bank and one on the bed.
Disturbed representative samples shall be collected from boreholes for visual classification of the sub soil at site.

Regions along the pipeline route where special excavation techniques like blasting, etc, is needed for excavation of pipeline trenches shall be clearly indicated in the soil investigation report.

7.2.4 Preparation of Right-of-Way

Construction activities shall be carried out within the width of the right-of-use set aside for construction of pipeline, unless other arrangements with the land owner/appropriate authorities are made. For trunk pipelines a minimum strip of 30 m right-of-use shall be used for construction. For smaller diameter pipelines of below 300 mm diameter, a minimum strip of 20 m right-of-use shall be used for construction.

Prior to clearing operations, the following shall be ensured:

a) Benchmarks, intersection points and other required survey monuments are installed;

b) Stake markers are placed in accordance with 7.2.2 as compared with the drawings;

c) Two right-of-use markers are staked at least at every 100 m; and

d) A reference line with respect to pipeline centre-line at a convenient location is set out, with markers on the reference line at a distance of a maximum 100 m for straight sections and a maximum 10 m for horizontal bends.

The right-of-use shall be graded and cleared of all obstacles as required for proper installation/laying of the pipeline and for providing access during construction.

7.3 Welding

Unless stated otherwise in the standard, all welding work including weld inspections, equipment of welding, heat treatment and welding personnel shall meet the requirements of API 1104. Unless otherwise specified elsewhere in the standard the requirements in ASME Boiler and Pressure Vessel Code, Section II C shall apply for filler materials and Section V shall apply for non-destructive examination of welds.

7.3.1 Welding Consumables, Equipments and Accessories

All consumables shall be suitable for the welding process and shall have the physical and chemical properties as that of pipe parent metal. The availability of sufficient number of welding and cutting equipment, equipment for heat treatment and other auxiliaries and accessories required for welding must be ensured.

7.3.2 Welding Processes

The specific process or combination of processes to be used shall be identified. The use of manual, semi-automatic or automatic welding process or any combination of these shall be as agreed between the contracting parties. Any of the following processes or combination of processes can be selected for main line and tie-ins:

a) Automatic gas metal arc welding (GMAW) from both sides or welding from outside with copper backing;

b) Semi-automatic GMAW with special controlled pulse waveform, capable of making root runs;

c) Shielded metal arc welding (SMAW) process for root and hot passes and semi-automatic GMAW/Flux core arc welding (FCAW) for fill and caps runs;

d) Shielded metal arc welding (SMAW) process; and

e) Double jointing of two pipe lengths using submerged arc welding (SAW)/automatic welding in specially laid pipe welding yard, where feasible, may also be used.

7.3.3 Inspection Before Welding and Markings

Wherever the original pipe length is cut into one or more pieces, the cut pieces used in main line welding shall have a minimum length of 1 m. Pipe identification details marked on the main pipe shall be transferred on each of the cut pieces.

The pipes shall be visually inspected for defects before taking up welding operation on them. Dents in pipes up to a depth equivalent to 2 percent of nominal pipe diameter shall be acceptable. However dents shall not be permitted within a length of 200 mm from the pipe ends. Dents due to stress concentration, up to 5 percent of the pipe wall thickness maybe permitted. An ovality of 1.5 mm at the pipe ends shall be acceptable. Bevel damage up to a depth of 1.00 mm may be accepted provided that such damage is removed by grinding. For bevel damages between 1.00 mm and 3.00 mm, the pipe end shall be re-bevelled as per the approved joint geometry. For bevel damages beyond 3.00 mm the pipe end shall be cut and re-bevelled.

The pipe bevels shall be cleaned and inspected before welding and the following ensured:

a) All bevel ends shall be free from rust, oil, grease, paint, oxide, sand, dust and surface irregularities;

b) Prior to making fit-up, pipe ends shall be cleaned at both inside and outside, using
power brush, to a minimum length of 25 mm from the edge so as to ensure that no surface damage/irregularities, rust, oil, grease, sand, dust, paint, etc. exists on the surface; 

c) If new bevels are made, the bevel surfaces shall be subjected to dye penetrant examination to ensure no lamination exists on new bevel surface; and 

d) If original pipe end is cut for a length of 20 mm or more, ultrasonic examination at pipe end shall be carried out on a minimum length of 20 mm on the entire circumference to ensure that no lamination/voids exist in the scanned area.

7.3.4 Weld Alignment and Spacing

The following requirements on the alignment and spacing of welds shall also be ensured:

a) Orientation of welded pipes shall be so selected as to ensure that at circumferential welds, the longitudinal welds are staggered in the top 90° of the pipe section or 250 mm, whichever is less. The longitudinal seam shall always be kept on the upper quadrant (between 315° and 45°);

b) A maximum offset of 1.6 mm at joints shall be permitted. Hot dressing shall not be allowed;

c) Root gap, subject to a maximum of 2 mm shall be provided in accordance with the qualified welding procedure;

d) Distance between skid on both sides of the weld joint shall be at a minimum possible in order to avoid sagging and mechanical stresses at the weld joint. The height of the skid shall provide sufficient and unobstructed access for carrying out welding operation; and

e) For pipe diameters of 250 mm and above, use of internal lineup clamps shall be mandatory. Internal lineup clamp shall be removed only on completion of root pass. External lineup clamp shall be provided on completion of a minimum of 60 percent of root pass, with proper supporting on both sides of weld joint. In tie-in welds, external lineup clamps may be used.

While welding pipes of different wall thicknesses, a special transition piece having a minimum taper in wall thickness of 1:4 shall be used. The weld shall be subject to both ultrasonic and radiographic examination.

7.3.5 Weld Procedure

7.3.5.1 Pre-heating where required shall be consistent with the established welding procedure using induction heating/flame torch coil. Pre-heating shall extend to a length of at least three times the thickness of the joint but shall not be less than 50 mm on both sides of the weld.

7.3.5.2 The welding procedure shall be qualified in accordance with the applicable specifications. Sequence of welding and number of welders shall be considered while qualifying the procedure.

7.3.5.3 The root pass shall be made with electrode/filler wires as specified in the approved welding process. The down hill welding shall be normally used for main line welding root pass. The vertical up method of welding shall be used for the root pass of tie-ins, special crossings, fittings and special parts, fillet welds and repairs. Unless otherwise specified, the weld projection inside the pipe shall not exceed 3 mm. Welding shall be continued uninterrupted during the root pass.

7.3.5.4 The actual time lapse between passes shall be in accordance with the established welding procedure. The following time lapse shall however be ensured:

a) In root and hot pass: maximum of 4 min; 

b) In hot pass and first filler: maximum of 5 min; and

c) In subsequent passes up to 50 percent wall thickness: maximum of 5 min.

Under no circumstances shall the welding be discontinued till 50 percent of wall thickness has been welded.

7.3.5.5 The completed weld shall be free from all visual defects like surface under cuts, weld spatters, pinholes, surface porosities, arc strikes, etc. Welds shall have a reinforcement 1.5 to 2.0 mm height, with good workmanship, smooth finish and without any surface irregularities. The completed weld joints, including 25 mm of pipe length on both sides of the weld, shall be properly cleaned using power brush.

7.3.5.6 The weld joint shall be numbered and marked along with the welder identification, adjacent to the weld joint on the progressing direction of main line in accordance with an approved numbering scheme.

7.3.5.7 Tie-in operations shall be carried out in accordance with the requirements specified in 7.4.12.

7.3.6 Weld Examination

7.3.6.1 Non-destructive examination shall be carried out on all girth welds. This shall be carried out preferably using on-line automatic ultrasonic testing (AUT) in case of all welds made by automatic GMAW with narrow bevels. Welds with API bevels may be examined either by radiography (X-Ray) or AUT. In
addition, radiographic examination shall also be required for first 100 weld joints corresponding to automatic GMAW welding procedure to establish accuracy of AUT. Radiography (X-Ray) shall be carried out for repaired welds. Tie-in and other welds testing. When pipe ends are cut for 20 mm or more in required for first 100 weld joints corresponding to IS 15663 (Part 1) :2006 welding process shall be subjected to ultra-sonic (X-Ray) or AUT.

7.3.6.2 The first ten joints welded using GMAW welding process shall be subjected to ultra-sonic testing. When pipe ends are cut for 20 mm or more in length, a minimum of 20 mm length of pipe at the ends shall be subjected to ultrasonic testing to ensure that no lamination exists. Weld repair areas shall also be subjected to ultrasonic testing in addition to radiography. If required, ultrasonic testing shall be required to confirm/clarify the defects indicated in radiographic examination.

7.3.6.3 Weld cuts for defects of any reasons shall be subjected to destructive testing similar to the destructive tests carried out for welding procedure qualification. If the results are not satisfactory, welding operations shall be suspended and shall not be restarted until the causes have been identified and appropriate measures adopted that would ensure acceptable results.

7.4 Installation of Pipelines

Pipe bevel protectors shall always be kept in position during all handling, transportation and stringing operations and shall be removed only prior to fill-up for welding. Visual inspection of the bare pipes and the coating of the corrosion coated pipes, as the case may be, must be performed and all damages shall be recorded. In the case of pipes coated for corrosion, holiday detection at a prescribed set voltage and recording of such holidays may be carried before transportation to the site. Repair of all such holidays found up to the time of laying the pipeline, shall be carried out before their burial.

7.4.1 Handling and Hauling of Line Pipes

Loading, unloading, transportation and stockpiling of the coated pipes shall be done using suitable means and in a manner so as to avoid damage to the pipe and coating. Use of round sectional slings shall not be permitted. Rolling, skidding or dragging shall also be strictly forbidden. Coated pipes at all times shall be stacked completely clear from the ground so that the bottom row of pipes remain free from any surface water. The pipes shall be stacked at a slope so that rain water does not accumulate inside the pipe. The coated pipes may be stacked by placing them on ridges of sand, free from stones and covered or on wooden supports provided with suitable cover. The supports shall be spaced in such a manner as to avoid permanent bending of the pipes, particularly in case of pipes with low wall thickness.

While lifting pipes, adequate care shall be taken not to kink or overstress the pipes. Proper approved pile slings shall be used. A strip of soft material shall be placed in between skid (of adequate width) and pipe to protect the external coating of the pipe. Skids shall not be removed under a string before lowering in. The welded pipes shall be maintained on skids at a minimum distance of 500 mm above the ground. Crotches shall be installed at frequent intervals (at least at every 10th support), with an increased number at bends and on undulating grounds

7.4.2 Stringing of Pipe

Stringing of pipe shall only be carried out in day light and after clearing and grading operation of the right-of-use has been completed. Pipes shall not be strung on the right-of-use in rocky areas where blasting may be required, until all blasting is complete and the area cleared of all debris. In case the line pipe supply is by different manufacturers, stringing of all line pipes of one manufacturer shall be completed before commencing the stringing of the line pipes of another manufacturer. The pipe lengths shall be properly spaced in order to facilitate easy handling during welding operations. The distance between the trench edge and the pipe string shall be such as to provide safe working space. Stringing shall be carried out in such a manner to cause minimum interference with public roads, footpaths, tracks, etc. All relevant identification marks available on pipes while stringing shall be recorded for traceability and material reconciliation.

7.4.3 Materials Other Than Line Pipes

Materials other than line pipes shall be stored in sheltered storage. Such materials shall not be strung on the right-of-use but shall be transported in covered conveyances for use only at the time of installation. It shall be ensured that all valves and whenever applicable, other materials are fitted with suitable end covers of the approved type. Materials with worked surfaces such as flanges, pipe-fittings, etc, shall be stacked and handled so as to avoid contact with the ground or with substances that could damage them. The manufacturer’s instructions regarding temperature and procedure for storing shall strictly be complied with for such materials whose properties/characteristics are liable to change due to unsuitable storage conditions. If required, adequate heat conditioning shall be provided for such materials. When supplied in containers and packages, they must not be thrown or dropped nor handled using hooks which could damage the container or the materials, either during loading/
unloading or during successive handling, till their final use.

7.4.4 Identification

All pipes and bends of size greater than 50 mm nominal bore shall be identified with a serial number as soon as possible, and accordingly indelibly marked on the pipes, along with the measured length. Pipes to be bent shall be measured prior to bending. Before a pipe length, pipe end, etc, is cut, the painted serial number and stamped-in pipe number shall be transferred to either side of the joint which is to be made by cutting and the changes shall be recorded, stating the new length.

7.4.5 Trenching

Pipeline trench shall be excavated and maintained on the staked centre-line of the pipeline, taking into account the curves of the pipeline. Normally trenching operation shall be carried out ahead of bending and stringing operations, unless otherwise required due to factors like terrain, climate, site conditions, etc.

7.4.5.1 Excavation

In cultivable land and other areas specifically designated, the top soil on the pipeline trench top width shall be excavated and stored separately. This top soil shall be replaced in original position after backfilling and compacting the rest of the trench. Suitable crossings shall be provided and maintained over the open right-of-use, where necessary, to permit general public, property owners or his tenants to cross or move stock or equipment from one side of the trench to the other. Care shall be exercised to see that fresh soil recovered from trenching operation and intended to be used for backfilling over the laid pipe in the trench, is not mixed with loose debris or foreign material. All sewers, drains, ditches and other natural waterways encountered in the execution of the works shall be maintained open and functional. The same would also apply to canals, irrigation canals, pipelines and buried facilities crossed by the trench for which temporary pipelines shall be laid, if required, and appropriate temporary installations provided.

7.4.5.2 Blasting

Blasting operations where considered necessary shall be carried out after obtaining required permission from statutory authorities and after ensuring all identified safety precautions. Blasting operation and removal of debris shall be carried out prior to stringing of pipes. Blasting for trenching and the removal of scattered rock and debris caused by the blasting from the right-of-use and/or adjacent property shall be carried out in the manner described herein. Every possible precaution shall be taken to prevent injuries and damages to persons and properties during blasting operations. All necessary precautions shall be taken to prevent stones from falling outside the right-of-use and in the cultivated areas and to avoid any damage to the installations and properties existing nearby. Blasting shall be carried out by qualified blasting personnel in accordance with statutory requirements on same.

7.4.5.3 Normal cover and trench dimensions

The pipeline shall be buried at a depth as to meet the cover requirements of 5.8.2. The trench shall be excavated to a minimum width so as to provide, on both sides of the installed pipeline, a clearance as indicated in the job standards/drawings and to a depth sufficient to provide the minimum cover as given in 5.8.2 and any requirement of padding (see 7.4.5.5).

7.4.5.4 Grades, bends and finish of trench

The trench shall be cut to a grade that will provide a firm, uniform and continuous support to the pipe. It is recommended to reduce the cold field bends to a minimum number to lay the pipeline conforming to the general contour of the ground and to maintain a normal cover. Finishing of the bottom of the trench should be done mechanically or manually, as necessary, to free the bottom of the trench from loose rock and hard clods and to trim protruding roots from the bottom and side walls of the trench.

7.4.5.5 Padding

In all cases where rock or gravel or hard soil is
encountered in the bottom of the trench, a padding shall be provided. The thickness of the compacted padding shall not be less than 150 mm. In those areas that are to be padded, the trench shall be at least 150 mm deeper than otherwise required. The trench shall be evenly and sufficiently padded to keep the pipe, when in place, at least 150 mm above bottom of excavated trench. The thickness of compacted padding on top of pipe corrosion coating shall be at least 150 mm. Graded soil/sand and/or other materials not containing gravel, rock or lumps of hard soil shall be considered as approved grading materials.

7.4.5.6 Protection of trench and other underground utilities

Trench shall be kept in good condition and protected from caving in. Wherever required, shuttering/buttress framing shall be provided in the trench (depending upon depth and side wall slopes and soil conditions) to avoid caving in.

Complete detail of underground utilities shall be obtained. Plans and full details of all existing and planned underground services from the relevant authorities shall be obtained and these plans shall be closely followed at all times during the performance of work. In locations where the use of trenching machine/backhoe may result in damage to property and subsurface structures, excavation shall be carried out manually. Where the pipeline crosses other underground utilities/structures, the excavation shall be carried out manually and in such a manner as to locate such utilities/structures.

7.4.5.7 Provisions for negative buoyancy to the pipe

In the case of water being encountered at the bottom of the ditch while laying the pipeline, the ditch shall be drained to enable visual inspection of the ditch bottom. The presence of water in the ditch after such inspection may be allowed provided that the water level does not cause sliding of the ditch sides and/or floating of the pipe when no concrete weighing is provided, before backfilling. Weighing of the pipelines in such instances shall be by any of the following methods:

- weighing by applying a continuous concrete coating around the pipe;
- weighing by installing saddle weights;
- installing metal anchors screwed into the subsoil in pairs;
- deeper burial of pipeline; and
- provision of select backfill material.

7.4.6 Bending

7.4.6.1 Changes of vertical and horizontal alignment shall preferably be provided by making elastic bends.

Optionally, cold field bends may be provided for change of direction and change of slope. A radius smaller than permitted in elastic bending shall however require a cold field bend.

7.4.6.2 Over bends shall be made in such a manner that the centre of the bend clears the high points of the trench bottom. Sag bends shall fit in the bottom of the trench and side bends shall confirm and leave specified clearance to the outside wall of the trench.

7.4.6.3 Cold field bends

The radius of cold field bends shall be as specified in 6.3.

Bending machines shall be capable of making bends without wrinkles, buckles, stretching and with minimum damage to the coating. A bending procedure shall be framed before start of work in accordance with the recommendations of the manufacturer of the bending machine. The procedure shall include amongst other steps the length, maximum degree per pull and method and accuracy of measurement during pulling of the bend.

Pipes with longitudinal welds shall be bent in such a way that the weld lies in the plane passing through the neutral axis of the bend, which shall be installed positioning the longitudinal weld in the upper quadrants. If horizontal deviations are to be achieved by joining a number of adjacent bends, the bending of the pipe lengths shall be made by positioning the longitudinal welds displaced by about 70 mm above and below the plane passing through the neutral axis in such a way that the bends are welded with the longitudinal welds in the upper quadrants. In case of vertical bends formed from a number of pipe lengths, the longitudinal welds shall be positioned on the plane passing through the neutral axis of the bend alternatively to the right and left.

The pads, dies and rolls of the bending equipment shall have relatively soft surfaces to avoid damage to the pipe coating.

The ends of each bent length shall be straight and not involved anyway in the bending. In no event shall the end of the bend be closer than 1.5 m from the end of a pipe or within one meter of a girth weld. The ovality in each pipe due to bending shall be less than 2.5 percent of the nominal diameter, at any point. A check shall be performed on all bends by passing a gauge consisting of two discs with a diameter equal to 95 percent of the nominal internal diameter of the pipe connected rigidly together at a distance equal to 300 mm.

The wall thickness of finished bends, taking into
account wall thinning at the outer radius, should not be less that the design wall thickness.

NOTE — An indication of wall thinning as a percentage, is given by the following empirical formula:

\[
\text{Wall Thinning} = \frac{50}{n + 1}
\]

where

\(n\) = inner bend radius divided by pipe diameter.

Pipes with measured wall thickness greater than the nominal wall thickness (with positive tolerance) shall normally be used for making cold field bends.

Cold bend pipes on site shall have the corrosion coating carefully checked with the aid of a holiday detector for cracks in the coating down to the pipe wall. Any defects or disbonding of the coating caused during bending (including forced ridges in the coating) shall be repaired.

7.4.6.4 Mitre and unsatisfactory bends

No mitre bends shall be permitted in the construction of the pipeline. Cutting of factory made bends and cold field bends for any purpose shall not be permitted. All bends showing buckling, wrinkles, cracks or other visible defects or which are in any way in disagreement, in whole or in part, with this specification shall be rejected.

7.4.7 Pipe Defects and Repairs

7.4.7.1 Dents

The depth of dent shall be measured as the gap between the lowest point of the dent and the original contour of the pipe. The maximum permissible depth of dents in pipes up to and including 324 mm nominal outside diameter shall be 5 mm. For pipes over 324 mm nominal outside diameter, the permissible depth of dent shall be 2 percent of the nominal pipe diameter.

Dents which contain scratch, gouge, burn or groove; and dents located at the longitudinal or circumferential weld shall be removed by cutting out a cylindrical portion containing the damaged portion of pipe. If due to cutting or repairs, the pipe identification number is removed, it shall be transferred onto the cut/repaired pipe. No pipe without identification number shall be transported and/or welded into the pipeline. Repair of damaged pipe ends by hammering and/or heating is not allowed. In case of minor dents located at least 200 mm from the pipe end may be straightened with the help of a jack provided the pipe metal is not split, severed or stretched.

7.4.7.2 Gouges, grooves and notches

Injurious gouge and grooves shall be removed by grinding to a smooth contour provided that the wall thickness is not reduced to less than the minimum specified. When the above conditions cannot be met, the damaged portion of the pipe shall be cut out and replaced with a good piece of pipe.

Notches on pipe surface can be caused by mechanical damage in manufacture, transportation, handling or installation. These shall be treated in a manner similar to gouges and grooves.

7.4.7.3 Arc burns

Metallurgical notch caused by arc burns shall be removed by grinding, provided that the grinding does not reduce the wall thickness to less than the minimum specified. Care shall be exercised to ensure that heat of grinding does not produce a metallurgical notch. In other cases the defective portion of the pipe shall be cut out and replaced with a good piece.

7.4.8 Night Caps

At the end of each day's work or when joining and welding operations are interrupted, the open ends on the welded strings of pipes shall be capped with a securely closed approved metal cap or plug. These covers shall not be removed until the work is to be resumed. The caps/plugs used shall be of mechanical type and shall not be attached to pipe by welding or by any other means which may dent, scratch or scar the pipe.

7.4.9 Lowering

7.4.9.1 Lowering in trench

Lowering shall commence after the removal of all off cuts, pipe supports, stones, roots, debris, stakes, rock projections up to 150 mm below underside of pipe and any other rigid materials which could lead to perforation or tearing of the coating, from the trench bottom. Sand padding and/or rock shield shall be provided as required. Lowering operation shall follow, as soon as possible, the joint coating of the pipeline.

Before lowering in, a complete check by a full circle holiday detector for pipe coating and for field joint coating shall be carried out and all damages repaired. All points on the pipeline where the coating has been in contact with either the skids or with the lifting equipment during the laying operation, shall be carefully inspected for damages, dents or other defects and shall be completely repaired. Before the last operation, a check must be made of the coating at points of contact with the supports. Short completed sections of the pipeline shall be cleaned with compressed air in order to remove dirt from the inside of pipe sections.

The pipeline shall be lifted and laid using, for all movements necessary, suitable equipment of non-abrasive material having adequate width considering the fragility of the coating. Care shall be exercised
while removing the slings from around the coated pipe after it has been lowered into the trench. No sling shall be put around field joint coating.

Wherever the pipeline is laid under tension, as a result of an assembly error (for example, incorrect positioning of bends, either horizontal or vertical), the trench shall be appropriately rectified.

7.4.10 Laying

Laying of the pipeline shall be carried out under safe conditions so as to avoid stresses and temporary deformations of the equipments which may cause damage to the pipeline itself and to the coating. The pipe shall be placed on the floor of the excavation, without jerking, falling, impact or other similar stresses. Care shall be taken that the deformation caused during the raising of the pipe string from the supports, does not exceed the values for minimum allowable radius of elastic curvature so as to keep the stresses on the steel and on coating within the safe limits. The portion of the pipeline between trench and bank shall be supported by as many side-booms or other equipment as required, for holding the line in gentle s-curve, maintaining the minimum elastic bend radius. Lowering in and back-filling shall preferably be carried out at the highest ambient temperature.

Movement of the pipe in a trench shall be prevented by appropriate means. Sand/earth filled bags shall be placed between parallel pipelines along the trench.

7.4.11 Backfilling

7.4.11.1 Backfilling shall not be carried out until the pipe and appurtenances have the proper fit, and the pipe follows the ditch profile at the required depth that will provide the required cover and has a bed which is free of extraneous material and which allows the pipe to rest smoothly and evenly.

7.4.11.2 Backfilling shall be carried out immediately after the pipeline has been laid in the trench. If immediate backfilling is not possible, a covering of at least 200 mm of earth, free of rock and hard lumps shall be placed over and around the pipe and coating. On no account shall the top soil from the right-of-use be used for this purpose. In general, the trench shall be dry during backfilling. The backfill material shall contain no extraneous material and/or hard lumps of soil, which could damage the pipe and/or coating or leave voids in the backfilled trench. The surplus material shall be neatly crowned directly over the trench and the adjacent excavated areas on both sides of the trench. The crown shall be high enough to prevent the formation of a depression in the soil when backfill has settled to its permanent position. Surplus material, including rock, left from this operation shall be disposed of to the satisfaction of landowner or the authority concerned. Rock, gravel, lumps of hard soil or like materials shall not be backfilled directly on to the pipes unless padding and/or rock shield has been provided.

7.4.11.3 Where rock, gravel, lumps of hard soil or like materials are encountered at the time of trench excavation, sufficient earth, sand or select backfill materials shall be placed around and over the pipe to form a protective cushion extending at least to a height of 150 mm above the top of the pipe. Loose rock may be returned to the trench after the required selected backfill materials has been placed, provided the rock placed in the ditch will not interfere with the subsequent use of the land.

7.4.11.4 When the trench has been dug through driveways or roads, all backfills shall be executed with sand or an approved suitable material and shall be thoroughly compacted. Any public or private authority having jurisdiction over a road, street or driveway may require that the surface of the backfill be graded with crushed rock or some other purchased material and the road shall be repaved. Trenches excavated in dikes, which are the property of railways or which are parts of main roads, shall be graded and backfilled in their original profile and condition. The trench in irrigated and paddy fields shall be backfilled to within 300 mm of the top, then rammed and further backfilled until the trench is completely backfilled.

7.4.11.5 At the end of each days work, backfilling shall not be more that 500 m behind the head end of lowered in pipe, which has been padded and approved for backfill. The backfill shall be maintained against washouts.

7.4.11.6 Breakers shall be installed in trenches in steep areas (slope of generally 10 percent and more) for the purpose of preventing erosion of the backfill. When backfilling the trenches in sloping terrains or steep areas, wherein the chances of washout of backfill exist, sheet piling or other effective water breakers across the trench shall be provided, to divert the flow of water away from the trench into normal drainage followed, before laying of the pipeline.

7.4.11.7 The maximum allowable deviation from the centre-line for land sections as staked out and after backfilling shall be limited to 200 mm for pipelines with pipe up to and including 600 mm nominal bore and 300 mm for pipelines of pipes larger than 600 mm nominal bore.
7.4.11.8 The backfill shall be stabilized with suitable materials. Temporary markers shall be installed during backfilling to locate the pipeline axis. These markers shall be subsequently replaced with permanent pipeline markers.

7.4.12 Tie-in

Tie-in shall preferably be carried out at ambient temperatures corresponding to the average operating temperature. The tie-in should be done in such a way as to leave a minimum of strain in the pipe. If necessary, realigning of the pipe with respect to the trench shall be carried out to eliminate any force or strain in the pipe.

7.4.12.1 Bell holes made to facilitate welding operations shall provide adequate clearance to enable the welders to exercise normal welding ability and skill. All tie-in welds shall be radiographically examined. If a pup end cannot be avoided for tie-in, a minimum length of 1 m shall be added and two or more such pups shall not be welded together. Tie-in with two or more pups may be used provided that each have a minimum length of 1 m and are separated by an entire length of pipe. In no case more than three welds shall be permitted on a 10 m length of pipeline. For tie-in of adjacent sections of pipeline already pressure tested, the pup used for tie-in shall be of single length or off-cuts of pipe which have already been hydrostatically tested.

7.4.13 Installation of Sectionalizing Valve and Valve Stations

The valve shall be installed only after the successful completion of hydrostatic test and dewatering. Valves shall be installed on suitable concrete foundation. Valves with flow arrows shall be installed according to the normal flow in the pipeline. During welding, the valves shall be in fully open position. In addition, all manufacturers instructions shall be followed in the installation of the valves. Care shall be taken to avoid entry of sand particles to valve body and seals during transportation, storage, assembly and installation. Valves and piping installed below ground shall be given any approved anti-corrosion coating/painting. The anti-corrosion coating below ground shall extend up to 300 mm above ground at the lowest point.

Sectionalizing valves shall be installed on sections of the pipeline in the horizontal position only. Installation shall be done in such a manner that there is no strain in the welded joint while the pipeline at upstream and downstream side are straight. All valves shall be handled using equipment and methods to avoid impact, shaking and other stresses. All sectionalizing valve and any other inline assemblies shall be prefabricated and tested hydrostatically ex-situ. The tie-in joints shall be radiographically examined over the entire length and ultrasonically examined prior to backfilling.

7.4.14 Installation of Insulating Joints

Insulating joint and welded joint shall be protected by an external coating.

The insulating joint shall be inserted on straight sections and laid on a fine sand-bed.

During the execution of the in-line connection welding, the propagation of heat shall be avoided. To achieve this, the joint shall be kept cold by means of continuous wetting using appropriate means.

Insulating joints shall be electrically tested before welding onto the pipeline. The insulation resistance across the joint shall be about one MΩ. The tests shall be repeated after installation and welding of the joint into the pipeline to verify that the assembly is undamaged.

7.4.15 Laying in Crossings

Crossings shall be laid in accordance with the applicable requirements in IS 15663 (Part 2).

7.5 Hydrostatic Testing

7.5.1 General

Hydrostatic pressure testing shall be carried out in accordance with the requirements specified in 5.9.

The number of test sections should be minimized taking into account safety of personnel and public; protection of environment and other facilities; sequence of construction; accessibility; and the availability and disposal of test water. Equipment that should not be subjected to the test pressure shall be isolated from the pipeline. Valves should not be used as end closures during pressure testing, unless they are designed to withstand the differential pressure across the valve during testing. All end closures shall have sufficient strength to withstand the test pressure. Individual components and fabricated items may be pretested in accordance with the provisions of this standard.

Work on or near a pipeline under test shall not be permitted for the period from the commencement of testing to the end of the test, except where necessary for the testing. Warning signs shall be placed and the pipeline route put under surveillance to prevent access to the pipeline during testing. In the case of pneumatic testing, the hazards from testing shall be taken into account when designing the safety requirement. The safety of the public, construction personnel, adjacent facilities and protection of the environment shall be ensured when depressurizing the pipe test medium.

A detailed pressure testing procedure shall be prepared
which shall include hydrostatic pressure test diagrams for each test section; filling and flushing procedures; equipments and instruments required, their locations and set up; type and sequence of pigs, pig tracking systems and pig inspection; estimated quantity of water required for testing; detection of leaks; dewatering and test data.

Hydrostatic test shall be commenced only after the completion of all mechanical and civil works (all welds have been accepted and pipeline laid and backfilled in accordance with the requirements of the standard).

7.5.2 Hydrostatic Test Section

Final hydrostatic pressure testing shall include all sections which have been previously tested like those at rail/road crossings, major water crossing, etc.

Based on actual gradient of pipeline section, it shall be ensured that test pressure at any location does not exceed or fall below the maximum and minimum permissible limits specified in 5.9.2. The maximum length of any test section shall not exceed 50 kms.

7.5.3 Test Pressure

The test pressure and the duration of testing shall be in accordance with that specified in 5.9.2. The duration of testing shall be considered from the time of stabilization of the test pressure. Pressure and temperature at start and end of the test shall be recorded.

7.5.4 Testing Equipments and Instruments

The following equipments/instruments shall be available for conducting the testing:

- a) Cleaning pigs;
- b) Four-cup batching pigs;
- c) Gauging pigs;
- d) Caliper pigs of appropriate accuracy to detect and locate deformities smaller than those permitted;
- e) Fill pumps of appropriate capacity;
- f) Portable tanks of sufficient size to ensure availability of continuous water during pressurization;
- g) Bourdon pressure gauges of accuracy of 0.01 kg/cm² and capable of measuring in increments of 0.05 kg/cm²;
- h) Two, 48 h recording pressure gauges with charts and ink gauges;
- i) Two temperature recorders for recording the temperature of filled water;
- j) Thermocouples for measuring pipe wall temperature;
- k) Two laboratory thermometers to be used in thermo-wells;
- l) Means to measure the volume of water necessary to drop the line pressure by 0.5 kg/cm²;
- m) Suitable communication equipment for a continuous communication between the beginning and the end of the test section for the inspection team along the line;
- n) Temporary scraper traps for launching and receiving of each pig independently; and
- o) Injection facilities to inject additives (inhibitors) into the test medium.

7.5.5 Test Procedure

The test medium shall be as specified in 5.9.1. Fresh water, well filtered, uncontaminated and free from sand/silt shall be used. Approved corrosion inhibitors, oxygen, scavengers, etc., shall be added to the water. Installation of temporary piping may, if required, be made to connect water source to the pumps and manifolds/tanks.

Pipeline shall be cleaned with air driven pigs for removing all mill scale, rust and sand from the inside of pipe sections before filling with test medium. The results for each pig run shall be analyzed for such purpose. No extraneous material shall be found in front of the last four-cup pig in cleaning. Results of the gauging pig run shall be analyzed for roundness along the pipeline.

Flushing of the pipeline section shall be done with uninhibited water equivalent of 10 percent of total volume of the section. Air vents shall be kept closed at the start of filling for the pressure build up.

Thermal stabilization after the inhibited water has been flushed for a minimum of 2 h, shall be considered to have been ensured when a difference of not more than 10°C, between the average values of the two temperature readings from thermocouples attached to external surface of pipe wall; and the pressure of at least 1 kg/cm² on the highest section has been attained.

Pressurization shall be done at a moderate and constant rate not exceeding 2 kg/cm²/min. Volume of water shall be recorded intermittently during pressurization. The pressurization cycle shall consist of the following steps:

- a) Pressurization to 50 percent of test pressure, holding pressure for 1 h and then dropping the pressure to static head,
- b) Pressurization to 75 percent of test pressure, holding pressure for 1 h and then dropping the pressure to static head, and
- c) Pressurization to test pressure.
Air volume calculation in each pressurization cycle shall be made. If a decrease in pressure is observed twice during the hold pressure period, the line shall not be considered suitable for testing. Presence of air in the piping shall be checked by means of air-volume calculation carried out as described below:

a) Two separate consecutive pressure lowering of 0.5 kg/cm² shall be carried out,

b) The volume of drained water corresponding to the second pressure lowering \( (V_p) \) shall be measured,

c) The theoretical volume \( (V_p') \) derived from calculations shall be compared with \( V_p \), and

d) The ratio \( V_p/V_p' \) shall be equal to 1.06 + 6 percent.

If the result meets the requirement, pressurization shall be continued or otherwise, additional pig passage shall be performed to remove the air pockets till the above requirement is fulfilled.

Test pressure shall be held for a minimum of 24 h after stabilization. After temperature and pressure have been stabilized, the injection pumps shall be disconnected and all connections at the test heads shall be checked for leakage. During the testing period, the pressure shall be measured every hour and the ambient and pipe wall temperature measured every 2 h. Bleed off water shall be accurately measured and recorded.

7.5.6 Acceptance Criteria

The test pressure shall remain constant throughout the test duration except for change due to temperature effects as evaluated. The pressure change due to alteration in temperature shall be algebraically added to the pressure read on the pressure gauges. This value shall be compared with the initial value and test shall be considered as acceptable if the difference is less than or equal to 0.3 kg/cm². In case of doubt, the test pressure shall be maintained for a further period of 24 h.

In the event of failure of the test section, the location of leakage or failure should be ascertained. All leaks and failures within the pipe wall or longitudinal seam shall be repaired by replacement of entire joint or joints in which the leakage/failure occurred. The method of repair shall be as approved by the owner. All defective pipes shall be identified.

7.5.7 Termination of Testing

Test shall be terminated with written approval of the inspection authority. Depressurization at a moderate and constant rate shall be ensured. Dewatering of the tested line shall be carried out in the manner described in 7.5.10.

7.5.8 Reporting

Proper record of the test should be maintained.

7.5.9 Precautions During the Test

Provision shall be made for the installation of precautionary warning signs and no-admittance sign to unauthorized persons from the roads to the right-of-use. Such areas shall be properly fenced to prevent access of unauthorized personnel. No unauthorized personnel shall be closer than 40 m to the pipeline or equipment under test. Provisional scraper traps shall be installed in compliance with methods and at suitable locations so that their rupture does not cause any injury/damage to personnel and property. Test section shall be placed in such locations as to prevent it from being affected by a catastrophic failure in the test head. After dewatering the line, the sectionalizing valves and other valve assemblies shall be installed. All thermo-couples installed, shall be removed and damaged coating shall be appropriately repaired.

7.5.10 Dewatering

Dewatering of a pipeline section shall be done subsequent to the hydrostatic test of the respective pipeline section using appropriately designed pigs. The disposal of the water shall be performed in accordance with applicable statutory requirements.

The dewatering operation for the pipeline shall consist of a number of dewatering pig runs and dry air shall be used as propellant for pig trains. Pigs shall be suitable for traversing the entire length of the pipeline/pipe segment. All the pigs shall be designed to prevent damage to the internal coating (if any) of the pipeline. The speed and the back pressure of the pigs shall be so maintained that continuous operation can be performed without the pig getting stuck.

Flushing of above ground piping at dispatch and receipt stations, sectionalizing valve stations, tap-off points and intermediate pigging stations shall be done with water to remove debris from piping and then with dry air to remove the residual amount of water from the above ground piping.

Before proceeding to next stage of operations, it shall be ensured that the bulk water has been removed from the pipeline system.
ANNEX A
(Clause 1)

NOTE — Facilities and piping indicated by solid lines are within the scope of the standard.

FIG. 1 FACILITIES AND PIPELINE SYSTEM COVERED UNDER THE STANDARD
ANNEX B
(Clause 4)
LIST OF APPLICABLE STATUTORY AND REGULATORY REQUIREMENTS

a) Environmental Protection Act, 1986
b) Environmental Protection Rules, 1986
c) Coastal Area Classification and Development Regulation
d) Manufacture Storage and Importation of Hazardous Chemicals Rules, 1989
e) Factories Act, 1948
f) Air (Prevention and Control) Act, 1981
g) Water (Prevention and Control) Act, 1974
h) Forest (Conservation) Act, 1980
i) Petroleum and Minerals Pipeline Act, 1962
j) Indian Electricity Rules, 1956.

ANNEX C
(Clause 5.2.4)
DETERMINATION OF LOCATION CLASS

C-1 Population density index along the pipeline route shall be determined as follows:

As zone, 400 m wide, shall be considered along the pipeline route with the pipeline in the centre-line of this zone. Then the entire route of the pipeline shall be divided into lengths of 1 600 m such that the individual lengths will include the maximum number of dwellings intended for human occupancy. The number of such dwellings which are intended of human occupancy within each 1 600 m zone shall be counted and reported along with other survey data.

C-2 Areas shall be classified based on guidelines as given below:

a) Class 1 Location — A class 1 location is any 1 600 m section that has 10 or fewer dwellings intended for human occupancy;
b) Class 2 Location — A class 2 location is any 1 600 m section that has more than 10 but less than 46 dwellings intended for human occupancy;
c) Class 3 Location — A class 3 location is any 1 600 m section that has 46 or more dwellings intended for human occupancy except when a Class 4 Location prevails; and
d) Class 4 Location — A class 4 location include areas where multi-storey buildings are prevalent, and where traffic is heavy or dense and where there may be numerous other utilities underground. Multi-storey means four or more floors above ground, including the ground floor and irrespective of depth of basement or number of floors of basement.

C-3 In addition to the criteria contained in C-2 (a) to (d), while classifying areas, additional consideration must be given to possibilities of increase in concentration of population along the pipeline route such as may be caused by the presence of schools, hospitals, recreational areas of an organized character, places of assembly, places of worship, etc. If one or more of these facilities are present, the area shall be classified as a Class 3 Location.

C-4 Notwithstanding the above, while determining class location of an area due consideration shall be given to the possibility of future development of the area during the design life of the pipeline. If it appears likely that future development may cause a change in the location class, this shall be taken into consideration while determining its class location.
ANNEX D
(Clauses 7.2.2.2)

PIPELINE ROUTE SURVEY DATA SHEET

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline size</td>
<td>mm</td>
</tr>
<tr>
<td>Gradient (ROU)</td>
<td>Along pipeline alignment, Max Across pipeline alignment, Max</td>
</tr>
<tr>
<td>Bend radius</td>
<td></td>
</tr>
<tr>
<td>Minimum distance between TPs</td>
<td></td>
</tr>
<tr>
<td>Maximum deflection angle at TP</td>
<td></td>
</tr>
<tr>
<td>Permissible variation in pipeline length</td>
<td></td>
</tr>
<tr>
<td>ROU width to be acquired</td>
<td></td>
</tr>
<tr>
<td>Pipeline location in the ROU</td>
<td></td>
</tr>
<tr>
<td>Minimum distances from existing:</td>
<td></td>
</tr>
<tr>
<td>habitable dwellings</td>
<td></td>
</tr>
<tr>
<td>buildings/structures/monuments</td>
<td></td>
</tr>
<tr>
<td>property corners/monuments</td>
<td></td>
</tr>
<tr>
<td>Co-ordinates of starting point</td>
<td>To be established on the alignment sheet prior to construction</td>
</tr>
</tbody>
</table>

NOTE — Number of TPs or bends in the pipeline, whether horizontal or vertical shall be kept to a minimum.
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This Indian Standard has been developed from Doc: No. CED 7 (7376).

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Printed at Simco Printing Press, Delhi