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Draft Zambian Standard

TRANSPORTATION PIPELINE SYSTEMS FOR LIQUID HYDROCARBONS – Code of Practice

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ZAMBIA BUREAU OF STANDARD
DATE OF PUBLICATION

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Engineering Institute of Zambia
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Ministry of Energy and Water Development, Department of Energy
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FOREWORD

This Zambian Standard has been prepared by the Technical Committee – Petroleum Products Pipelines (BCD TC2/13), in accordance with the procedures of the Bureau.

The absence of official national specifications or standards with respect to environmental, safety and operational issues associated with pipeline transportation of petroleum products and other liquid hydrocarbons, necessitated the formation of a technical committee to develop standards in this field. This Technical Committee was therefore set up under the auspices of the Zambia Bureau of Standards and facilitated by the Energy Regulation Board.

This code of practice takes into consideration the social and economic factors prevailing in the country and the various good engineering pipeline practices and requirements throughout the world.

In the preparation of this standard, reference was made to the following publications:

ASME B31.4 - 1992 liquid transportation systems for hydrocarbons, liquid petroleum gas, anhydrous ammonia, and alcohols

COMPLIANCE WITH A ZAMBIAN STANDARD DOES NOT OF ITSELF CONFER IMMUNITY FROM LEGAL OBLIGATIONS
1.0 INTRODUCTION

Where the word “Code” is used without specific identification, it means this Code of Practice.

The Code sets forth engineering requirements deemed necessary for safe design and construction of pressure piping. While safety is the basic consideration, this factor alone will not necessarily govern the final specifications for any piping system. The designer is cautioned that the Code is not a design handbook; it does not do away with the need for the designer or for competent engineering judgment.

To the greatest possible extent, Code requirements for design are stated in terms of basic design principles and formulas. These are supplemented as necessary with specific requirements to assure uniform application of principles and to guide selection and application of piping elements. The Code prohibits designs and practices known to be unsafe and contains warnings where caution, but not prohibition, is warranted.

This Code of Practice includes:

a) references to acceptable material specifications and component standards, including dimensional requirements and pressure-temperature ratings;
b) requirements for design of components and assemblies, including pipe supports;
c) requirements and data for evaluation and limitation of stresses, reactions and movements associated with pressure, temperature changes and other forces;
d) guidance and limitations on the selection and application of materials, components and joining methods;
e) requirements for the fabrication, assembly and erection of piping;
f) requirements for examination, inspection, and testing of piping;
g) procedures for operation and maintenance that are essential to public safety and;
h) provisions for protecting pipelines from external corrosion and internal corrosion/erosion.

2.0 SCOPE

2.1 GENERAL STATEMENTS

a) The requirements of this Code are adequate for safety under conditions normally encountered in the movement of liquid petroleum by pipelines. Requirements for all abnormal or unusual conditions are not specifically provided for, nor are all details of engineering and construction prescribed. All work, performed within the scope of this Code shall comply with the safety standards expressed or implied.

b) The primary purpose of this Code is to establish requirements for safe design, construction, inspection, testing, operation and maintenance of liquid hydrocarbons transportation piping systems for protection of the general public and operating company personnel as well as for reasonable protection of the piping system against vandalism and accidental damage by others and reasonable protection of the environment.

c) This Code is concerned with employee safety to an extent that it is affected by basic design, quality of materials and workmanship and requirements for construction, inspection, testing, operation and maintenance of liquid and hydrocarbons transportation piping systems. Existing industrial safety regulations pertaining to work areas, safe
work practices and safety devices are not intended to be supplanted by this Code.

d) The designer is cautioned that the Code is not a design handbook. The Code does not do away with the need for the engineer or competent engineering judgment. The specific design requirements of the Code usually revolve around a simplified engineering judgment. The specific design requirements of the Code usually revolve around a simplified engineering approach to a subject. It is intended that a designer capable of applying more complete and rigorous analysis to special or unusual problems shall have latitude in the development of such designs and the evaluation of complex or combined stresses. In such cases the designer is responsible for demonstrating the validity of his approach.

e) This Code shall not be retroactive or construed as applying to piping systems installed before date of issuance shown on document title page insofar as design, materials, construction, assembly, inspection and testing are concerned.

2.2 This code prescribes requirements for the design, materials, construction, assembly, inspection and testing such as crude oil condensate, natural gasoline, natural gas liquids, liquefied petroleum gas, liquid petroleum and petroleum products between producers lease facilities, tank farms, refineries, stations, terminals (marine, rail and truck) and other deliveries and receiving points. (see figure 1.)

Piping consists of pipe flanges, bolting gaskets, valves, relief devices, fittings and the pressure containing parts of other piping components. It also includes hangers and supports, and other equipment items necessary to prevent overstressing the pressure containing parts. It does not include support structures such as frames of buildings, stanchions, or foundations, or any equipment such as defined in 2.3(b). Also included within the scope of this Code are:

a) primary and associated auxiliary liquid petroleum at pipeline terminals (marine, rail and truck, tank farms, pump stations, pressure reducing stations and metering stations including scraper traps, strainers and prover loops;
b) storage and working tanks including pipe type storage fabricated from pipe and fittings, and piping interconnecting these facilities;
c) liquid petroleum piping located on property which has been set aside for such piping within petroleum refinery, natural gasoline, gas processing, ammonia and bulk plants;
d) Those aspects of operation and maintenance of liquid petroleum transportation piping systems relating to the safety and protection of the general public, operating company personnel, environment, property and the piping systems. [see sections 2.1 (b) and (c)].

2.3 This Code does not apply to:

a) auxiliary piping such as water, air, steam, lubricating oil, gas, and fuel;
b) pressure vessels, heat exchangers, pumps, meters, and other such equipment including internal piping and connection for piping except as limited in section 7.1.2.3(b);
c) piping designed for internal pressures;
   1) At or below 1 bar (15 psi) gauge pressure regardless of temperature;
   2) Above 1 bar gauge (15 psi) pressure if design temperature is below -30°C (20°F) or above 120°C (250°F);
d) casing, tubing or pipe used in oil wells, wellhead assemblies, oil and gas sesctiontors, crude oil production tanks, other producing facilities and pipelines interconnecting these facilities;
e) petroleum refinery, natural gasoline, gas processing and bulk plant piping except as covered under section 2.2(e);
f) gas transmission and distribution piping;
g) the design and fabrication of proprietary items of equipment, apparatus, or instruments except as limited by section 7.1.2.3(b);
Figure 1. Diagram showing scope of ASME B31.4

The requirements of this code are adequate for safety under conditions normally encountered in the movement of liquid hydrocarbons by pipelines.
3.0 NORMATIVE REFERENCES

The following standards and normative documents contain provisions, which, through reference in this text, constitute provisions of this standard. All standards and normative references are subject to revision and, since any reference to a standard or normative document is deemed to be a reference to the latest edition of that standard or normative reference, parties to agreements based on this standard are encouraged to take steps to ensure the use of the most recent editions of the standards and normative documents indicated below.

In the preparation of this standard, reference was made to the following publications:

ASME B31.4 liquid transportation systems for hydrocarbons, liquid petroleum gas, anhydrous ammonia, and alcohols

ZS 385-1 The Petroleum Industry - Code of Practice
   Part 1: Storage and distribution of petroleum products in aboveground bulk installations

ZS 385-2 The Petroleum Industry – Code of Practice
   Part 2: Electrical installations in the distribution and marketing sector

ZS 402 The Classification of Hazardous Locations and the Selection of Electrical Apparatus for Use in Such Locations - Code of Practice

   Part 2: Tank Cleaning Safety Code

4.0 DEFINITIONS

For the purpose of this standard, the following definitions shall apply:

Defect - an imperfection of sufficient magnitude to warrant rejection

engineering design – the detailed design developed from operating requirements and conforming to Code requirements, including all necessary drawings and specifications, governing a piping installation.

Circumferential (girth)) weld - a complete circular butt weld joining pipe or components

imperfection – a discontinuity or irregularity which is detected by inspection.

Internal design pressure – internal pressure used in calculations or analysis for pressure design of a piping component (see section 6.12.1).

liquefied petroleum gas(s) (LPG) – liquid petroleum composed predominantly of the following hydrocarbons, either by themselves or a mixtures: butane (normal butane or isobutene), butylenes (including isomers) propane, propylene, and ethane

liquid alcohol – any of a group of organic compounds containing only hydrogen, carbon, and one or more hydroxyl radicals which will remain liquid in a moving stream in a pipeline

maximum steady state operating pressure – maximum pressure (sum of static head pressure, pressure required to overcome friction losses, and any back pressure) at any point in a piping system when the system is operating under steady state conditions

mitre – two or more straight sections of pipe matched and joined on a line bisecting the angle of junction so as to produce a change in direction

nominal pipe size (NPS) – Internal diameter of the pipe
offshore – area beyond the line of ordinary high water, along the portion of the coast that is in direct contact with the open seas and beyond the line marking the seaward limit or inland coastal waters.

operating company – owner or agent currently responsible for the design, construction, inspection, testing, operation, and maintenance of the piping system

petroleum – crude oil, condensate, natural gasoline, natural gas liquids, liquefied petroleum gas, and liquid petroleum products.

Pipe – a tube, usually cylindrical, used for conveying a fluid or transmitting fluid pressure, normally designated “pipe” in the applicable specification. It also includes any similar component designated as “tubing” used for the same purpose. Types of pipe, according to the method of manufacture, are defined as follows.

a) electrical resistance welded pipe – pipe produced in individual lengths or in continuous lengths from coiled skelp, having a longitudinal or spiral butt joint wherein coalescence is produced by the heat obtained from resistance of the pipe to the flow of electric current in a circuit of which the pipe is a part, and by the application of pressure

b) furnace lap welded pipe – pipe having a longitudinal lap joint made by the forge welding process wherein coalescence is produced by heating the preformed tube to welding temperature and passing it over a mandrel located between two welding rolls which compress and weld the overlapping edges

c) furnace butt welded pipe

1) furnace butt welded pipe, bell welded – pipe produced in individual lengths from cut-length skelp, having its longitudinal butt joint forge welded by the mechanical pressure developed in drawing the furnace heated skelp through a cone-shaped die (commonly known as the “welding bell”) which serves as a combined forming and welding die

2) furnace butt welded pipe, continuous welded – pipe produced in continuous lengths from coiled skelp and subsequently cut into individual lengths, having its longitudinal butt joint forge welded by the mechanical pressure developed in rolling the hot formed skelp through a set of round pass welding rolls

d) electric fusion welded pipe – pipe having a longitudinal or spiral butt joint wherein coalescence is produced in the preformed tube by manual or automatic electric arc welding. The weld may be single or double and may be made with or without the use of filler metal. Spiral welded pipe is also made by the electric fusion welded process with either a lap joint or a lock-seam joint.

e) electric flash welded pipe – pipe having a longitudinal butt joint wherein coalescence is produced simultaneously over the entire area of abutting surface by the heat obtained from resistance to the flow of electric current between the two surfaces, and by the application of pressure after heating is substantially completed. Flashing and upsetting are accompanied by expulsion of metal from the joint.

f) Double submerged arc welded pipe – pipe having a longitudinal or spiral butt joint produced by at least two passes, one of which is on the inside of the pipe. Coalescence is produced by heating with an electric arc or arcs between the bare metal electrode or electrodes and the work. The welding is shielded by a blanket of granular, fusible material on the work. Pressure is not used and filler metal for the inside and outside welds is obtained from the electrode or electrodes.

g) Seamless pipe – pipe produced by piercing a billet followed by rolling or drawing, or both

h) Electric induction welded pipe – pipe produced in individual lengths or in continuous lengths from coiled skelp having a longitudinal or spiral butt joint wherein coalescence is produced by the heat obtained from resistance of the pipe to induced electric current, and by application of pressure.

Pipe nominal wall thickness – the wall thickness listed in applicable pipe specifications or dimensional standards included in this Code by reference. The listed wall thickness dimension is subject to tolerances as given in the specification or standard.
**pipe supporting elements** – pipe supporting elements consist of fixtures and structural attachments as follows.

**fixtures** – fixtures include elements which transfer the load from the pipe or structural attachment to the supporting structure or equipment. They include hanging type fixtures such as hanger roads, spring hangers, sway braces, counterweights, turnbuckles, struts, chains, guides and anchors, and bearing type fixtures such as saddles, bases, rollers, brackets, and sliding supports.

**structural attachments** – structural attachments include elements which are welded, bolted, or clamped to the pipe, such as clips, lugs, rings, clamps, clevises, straps, and skirts.

**Pressure** – unless otherwise stated, pressure is expressed in pounds per square inch (bar) above atmospheric pressure, i.e., gauge pressure as abbreviated – psig (bar).

**Shall** – “shall” or “shall not” is used to indicate that a provision is mandatory.

**Should** – “should” or “it is recommended” is used to indicate that a provision is not mandatory but recommended as good practice.

**temperatures** are expressed in degrees Celsius (°C) unless otherwise stated.

**Arc welding** – a group of welding processes wherein coalescence is produced by heating with an electric arc or arcs, with or without the application of pressure and with or without the use of filler metal.

**Automatic welding** – welding with equipment which performs the entire welding operation without constant observation and adjustment of the controls by the operator. The equipment may or may not perform the loading and unloading of the work.

**Fillet weld** – a weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, tee joint, or corner joint.

**Full fillet weld** – a fillet weld whose size is equal to the thickness of the thinner member joined.

**Gas welding** – a group of welding processes wherein coalescence is produced by heating with a gas flame or flames, with or without the application of pressure, and with or without the use of filler metal.

**Gas metal arc welding** – an arc welding process wherein coalescence is produced by heating with an electric arc between a filler metal (consumable) electrode and the work. Shielding is obtained from a gas, a gas mixture (which may contain an inert gas) or a mixture of a gas and a flux. (This process has sometimes been called Mig welding or CO₂ welding.)

**Hydrocarbons** – a chemical compound of hydrogen and carbon.

**Gas tungsten arc welding** – an arc welding process wherein coalescence is produced by heating with an electric arc between a single tungsten (nonconsumable) electrode and the work. Shielding is obtained from a gas or gas mixture (which may contain an inert gas). Pressure may or may not be used and filler metal may or may not be used. (This process has sometimes been called Tig welding.)

**Semiautomatic arc welding** – arc welding with equipment which controls only the filler metal feed. The advance of the welding is manually controlled.

**Shielded metal arc welding** – an arc welding process wherein coalescence is produced by heating with an electric arc between a covered metal electrode and the work. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

**Submerged arc welding** – an arc welding process wherein coalescence is produced by heating with an electric arc or arcs between a bare metal electrode or electrodes and the work. The welding is shielded by a blanket of granular,
fusible material on the work. Pressure is not used, and filler metal is obtained from the electrode and sometimes from a supplementary welding rod.

_Tack weld_* - a weld made to hold parts of a weldment in proper alignment until subsequent welds are made

_Weld_* - a localized coalescence (fusion) of metal wherein coalescence is produced by heating to suitable temperatures, with or without the application of pressure, and with or without the use of filler metal. The filler metal shall have a melting point approximately the same as the base metal.

_Welder_* - one who is capable of performing a manual or semiautomatic welding operation

_Welding operator_* - one who operates machine or automatic welding equipment

_Welding procedures_* - the detailed methods and practices including joint welding procedures involved in the production of a weldment.

### 5.0 SYMBOLS AND ABBREVIATIONS

API - American Petroleum Institute  
ANSI - American National Standards Institute, Inc  
ASME - American Society of Mechanical Engineers  
ASTM - American Society for Testing and Materials  
ERB - Energy Regulation Board  
ISO - International Organisation for Standardisation  
mm - millimetres  
% - Percentage  
MSS - Manufacturers Standardisation Society of the Valve and Fittings Industry, Inc  
NACE - National Association of Corrosion Engineers  
NFPA - National Fire Protection Association  
NPS - Nominal Pipe Size  
SABS - South African Bureau of Standards  
ZABS - Zambia Bureau of Standards  
ZS - Zambian Standard

### 6.0 DESIGN

_part 1 – CONDITIONS AND CRITERIA_

#### 6.1 DESIGN CONDITIONS

##### 6.1.1 General

The following section defines the pressures, temperatures, and various forces applicable to the design of piping systems within the scope of this Code. It also takes into account considerations that shall be given to ambient and mechanical influences and various loadings.

##### 6.1.2 Pressure

**6.1.2.1 Internal Design Pressure**

The piping component at any point in the piping system shall be designed for any internal design pressure which shall not be less than the maximum steady state operating pressure at that point, or less than the static head pressure at that point, with the line in a static condition. The maximum steady state operating pressure shall be the sum of the static head pressure, pressure required to overcome friction losses, and any required back pressure. Credit may be given for hydrostatic external pressure, in the appropriate manner, in modifying the internal design pressure for use in calculations involving the pressure design of piping components (see section 6.4.1.3). Pressure rise above maximum
steady state operating pressure due to surges and other variations from normal operations is allowed in accordance with section 6.2.2.4

6.1.2.2 External Design Pressure
The piping component shall be designed to withstand the maximum possible differential between external and internal pressures to which the component will be exposed.

6.1.3 Temperature
6.1.3.1 Design Temperature
The design temperature is the metal temperature expected in normal operation. It is not necessary to vary the design stress for metal temperature between -30°C (20°F) and 120 °C (250°F). However, some of the materials conforming to specifications approved for use under this Code may not have properties suitable for the lower portion of the temperature band covered by this Code. Engineers are cautioned to give attention to the low temperature properties of the materials used for facilities to be exposed to unusually low ground temperatures or low atmospheric temperatures.

6.1.4 Ambient Influences
6.1.4.1 Fluid Expansion Effects
Provision shall be made in the design either to withstand or to relieve increased pressure caused by the heating of static fluid in a piping component.

6.1.5 Dynamic Effects
6.1.5.1 Impact
Impact forces caused by either external or internal conditions shall be considered in the design of piping systems.

6.1.5.2 Wind
The effect of wind loading shall be provided for the design of suspended piping.

6.1.5.3 Earthquake
Consideration in the design shall be given to piping systems located in regions where earthquakes are known to occur.

6.1.5.4 Vibration
Stress resulting from vibration or resonance shall be considered and provided for in accordance with sound engineering practice.

6.1.5.5 Subsidence
Consideration in the design shall be given to piping systems located in regions where subsidence is known to occur.

6.1.5.6 Waves and Currents
The effects of waves and currents shall be provided for in the design of pipelines across waterways and offshore.

6.1.6 Weight Effects
The following weight effects combined with loads and forces from other causes shall be taken into account in the
design of piping that is exposed, suspended, or not supported continuously.

6.1.6.1 **Live Loads**

Live loads include the weight of the liquid transported and any other extraneous materials that adhere to the pipe. The impact of wind, waves, and currents are also considered live loads.

6.1.6.2 **Dead Loads**

Dead loads include the weight of the pipe, components, coating, backfill, and unsupported attachments to the piping.

6.1.7 **Thermal Expansion and Contraction Loads**

Provisions shall be made for the effects of thermal expansion and contraction in all piping systems.

6.1.8 **Relative movement of Connected Components**

The effect of relative movement of connected components shall be taken into account in design of piping and pipe supporting elements.

6.2 **DESIGN CRITERIA**

6.2.1 **General**

This chapter pertains to ratings, stress criteria, design allowances, and minimum design values, and formulates the permissible variations to these factors used in the design of piping systems within the scope of this Code.

The design requirements of this Code are adequate for public safety under conditions usually encountered in piping systems within the scope of this Code, including lines within villages, towns, cities, and industrial areas. However, the design engineer shall provide reasonable protection to prevent damage to the pipeline from unusual external conditions which may be encountered in river crossings, offshore and inland coastal water areas, bridges, areas of heavy traffic, long self-supported spans, unstable ground, vibration, weight of special attachments, or forces resulting from abnormal thermal conditions. Some of the protective measures which the design engineer may provide are encasing with steel pipe of larger diameter, adding concrete protective coating, increasing the wall thickness, lowering the line to a greater depth, or indicating the presence of the line with additional markers.

6.2.2 **Pressure-Temperature Ratings for Piping Components**

6.2.2.1 **Components Having Specific Ratings**

Within the metal temperature limits of -30°C (-20°F) and 120 °C (250°F) pressure ratings for components shall conform to those stated for 40 °C (100°F) in material standards listed in Table 4. The non-metallic trim, which are not injuriously affected by the fluid in the piping system and shall be capable of withstanding the pressures and temperatures to which they will be subjected in service.

6.2.2.2 **Ratings – Components Not Having Specific Ratings**

Piping components not having established pressure ratings may be qualified for use as specified in section 6.4.6 and 7.1.1.

6.2.2.3 **Normal Operating Conditions**

For normal operation the maximum steady state operating pressure shall not exceed the internal design pressure and pressure ratings for the components used.

6.2.2.4 **Ratings – Allowance for Variations From Normal Operations**
Surge pressure in a liquid pipeline are produced by a change in the velocity of the moving stream that results from shutting down of a pump station or pumping unit, closing of a valve, or blockage of the moving stream.

Surge pressure attenuates (decreases in intensity) as it moves away from its point of origin.

Surge calculations shall be made, and adequate controls and protective equipment shall be provided, so that the level of pressure rise due to surges and other variations from normal operations shall not exceed the internal design pressure at any point in the piping system and equipment by more than 10%.

6.2.2.5 Rating – Considerations for Different Pressure Conditions

When two lines that operate at different pressure conditions are connected, the valve segregating the two lines shall be rated for the more severe service condition. When a line is connected to a piece of equipment which operates at a higher pressure condition than that of the line, the valve segregating the line from the equipment shall be rated for at least the operating condition of the equipment. The piping between the more severe conditions and the valve shall be designed to withstand the operating conditions of the equipment or piping to which it is connected.

6.2.3 Allowable Stresses and Other Stress Limits

6.2.3.1 Allowable Stress Values

a) The allowable stress value $S$ to be used for design calculations in section 6.4.1.2 for new pipe of known specification shall be established as follows:

$$S = 0.72 \times E \times \text{specified minimum yield strength of the pipe, psi (MPa)}$$

Where

- $0.72$ = design factor based on nominal wall thickness. In setting design factor, due consideration has been given to and allowance has been made for underthickness tolerance and maximum allowable depth of imperfections provided for in the specifications approved by the Code.

- $E$ = Weld joint factor (see section 6.2.4.3 and Table 2)

Table 1 is a tabulation of examples of allowable stresses for reference use in transportation piping systems within the scope of this Code.

b) The allowable stress value $S$ to be used for design calculations in section 6.4.1.2 for used (reclaimed) pipe of known specification shall be in accordance with (a) above and limitations in section 6.5.1.1(b)

c) The allowable stress value $S$ to be used for design calculations in section 6.4.1.2 for new or used (reclaimed) pipe of unknown or ASTM A 120 or its equivalent specification shall be established in accordance with the following and limitations in section 6.5.1.1 (c)

$$S = 0.72 \times E \times \text{minimum yield strength of the pipe, MPa (psi) [165 MPa (24,000 psi) or yield strength determined in accordance with section 10.2.3.6 and 10.2.3.7}$$

Where

- $0.72$ = designed factor based on nominal wall thickness. In setting design factor, due consideration has been given to and allowance has been made for the underthickness tolerance and maximum allowable depth of imperfections provided for in the specifications approved by the Code.

- $E$ = Weld joint factor (see Table 2)

d) The allowable stress value $S$ to be used for design calculations in section 6.4.1.2 for pipe which has been cold worked in order to meet the specified minimum yield strength and is subsequently heated to 300 °C (600 °F) or higher
(welding excepted) shall be 75% of the applicable allowable stress value as determined by section 6.2.3.1(a), (b), or (c).

e) Allowable stress value in shear shall not exceed 45% of the specified minimum yield strength of the pipe, and allowable stress values in bearing shall not exceed 90% of the specified minimum yield strength of the pipe.

f) Allowable tensile and compressive stress values for materials used in structural supports and restraints shall not exceed 66% of the specified minimum yield strength. Allowable stress values in shear and bearing shall not exceed 45% and 90% of the specified minimum yield strength respectively. Steel materials of unknown specifications may be used for structural supports and restraints, provided a yield strength of 165 MPa (24,000 psi) or less is used.

g) In no case where the Code refers to the specified minimum value of a physical property shall a higher value of the property be used in establishing the allowable stress value.

6.2.3.2 Limits of Calculated Stress Due to Sustained Loads and Thermal Expansion

a) Internal Pressure Stresses. The calculated stresses due to internal pressure shall not exceed the applicable allowable stress value \( S \) determined by section 6.2.3.1(a), (b), (c), or (d) except as permitted by other subsections of section 6.2.3

b) External Pressure Stresses. Stresses due to external pressure shall be considered safe when the wall thickness of the piping components meets the requirements of section 6.3 and section 6.4

c) Allowable Expansion Stress. The allowable stress values for the equivalent tensile stress in section 6.14.3.4 (b) for restrained lines shall not exceed 90% of the specified minimum yield strength of the pipe. The allowable stress range \( S_A \) in 6.14.3.4 (c) for unrestrained lines shall not exceed 72% of the specified minimum yield strength of the pipe.

d) Additive Longitudinal Stresses. The sum of the longitudinal stresses due to pressure, weight, and other sustained external loadings [see section 6.14.3.4 (c)] shall not exceed 75% of the allowable stress value specified for \( S_A \) in (c) above.

e) Additive Circumferential Stresses. The sum of the circumferential stresses due to internal design pressure and external load in pipe installed under railroads or highways without use of casing [see section 9.1.13.4 (c)] shall not exceed the applicable allowable stress value \( S \) determined by section 6.2.3.1 (a), (b), (c), or (d).

6.2.3.3 Limits of Calculated Stresses Due to Occasional Loads

a) Operation. The sum of the longitudinal stress produced by pressure, live and dead loads, and those produced by occasional loads, such as wind or earthquake, shall not exceed 80% of the specified minimum yield strength of the pipe. It is not necessary to consider wind and earthquake as occurring concurrently.

b) Test. Stresses due to test conditions are not subject to the limitations of section 6.2.3 it is not necessary to consider other occasional loads, such as wind and earthquake, as occurring concurrently with the live, dead, and test loads existing at the time of test.

6.2.4 Allowances

6.2.4.1 Corrosion

A wall thickness allowance for corrosion is not required if pipe and components are protected against corrosion in accordance with the requirements and procedures prescribed in Section 12

6.2.4.2 Threading and Grooving

An allowance for thread or groove depth in inches (mm) shall be included in A of the equation under section 6.4.1 when threaded or grooved pipes allowed by this Code (section 6.12)
6.2.4.3  Weld Joint Factors

Longitudinal or spiral weld joint factors $E$ for various types of pipe are listed in Table 2.

**TABLE 1 - TABULATION OF EXAMPLES OF ALLOWABLE STRESSES FOR REFERENCE USE IN PIPING SYSTEMS WITHIN THE SCOPE OF THIS CODE**

<table>
<thead>
<tr>
<th>Specification (MPa)</th>
<th>Grade</th>
<th>Specified Min. Yield Strength, psi (MPa)</th>
<th>Weld Joint Factor $E$</th>
<th>Allowable Stress $-20^\circ$F to $250^\circ$F (-30$^\circ$C to 120$^\circ$C) psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seamless</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>API 5L</td>
<td>25</td>
<td>25,000 (172)</td>
<td>1.00</td>
<td>18,000 (124)</td>
</tr>
<tr>
<td>API 5L, ASTM A 53, ASTM A 106 A</td>
<td></td>
<td>30,000 (207)</td>
<td>1.00</td>
<td>21,600 (149)</td>
</tr>
<tr>
<td>API 5L, ASTM A 53, ASTM A 106 B</td>
<td></td>
<td>35,000 (241)</td>
<td>1.00</td>
<td>25,200 (174)</td>
</tr>
<tr>
<td>API 5 LU</td>
<td>U80</td>
<td>80,000 (554)</td>
<td>1.00</td>
<td>57,600 (397)</td>
</tr>
<tr>
<td>API 5 LU</td>
<td>U100</td>
<td>100,000 (689)</td>
<td>1.00</td>
<td>72,000 (496)</td>
</tr>
<tr>
<td>API 5 L</td>
<td>X42</td>
<td>42,000 (289)</td>
<td>1.00</td>
<td>30,250 (208)</td>
</tr>
<tr>
<td>API 5 L</td>
<td>X46</td>
<td>46,000 (317)</td>
<td>1.00</td>
<td>33,100 (228)</td>
</tr>
<tr>
<td>API 5 L</td>
<td>X52</td>
<td>52,000 (358)</td>
<td>1.00</td>
<td>37,450 (258)</td>
</tr>
<tr>
<td>API 5 L</td>
<td>X56</td>
<td>56,000 (386)</td>
<td>1.00</td>
<td>40,300 (278)</td>
</tr>
<tr>
<td>API 5 L</td>
<td>X60</td>
<td>60,000 (413)</td>
<td>1.00</td>
<td>43,200 (298)</td>
</tr>
<tr>
<td>API 5 L</td>
<td>X65</td>
<td>65,000 (448)</td>
<td>1.00</td>
<td>46,800 (323)</td>
</tr>
<tr>
<td>API 5 L</td>
<td>X70</td>
<td>70,000 (482)</td>
<td>1.00</td>
<td>50,400 (347)</td>
</tr>
<tr>
<td>ASTM A 106</td>
<td>C</td>
<td>40,000 (278)</td>
<td>1.00</td>
<td>28,800 (199)</td>
</tr>
<tr>
<td>ASTM A 524</td>
<td>I</td>
<td>35,000 (241)</td>
<td>1.00</td>
<td>25,200 (174)</td>
</tr>
<tr>
<td>ASTM A 524</td>
<td>H</td>
<td>30,000 (207)</td>
<td>1.00</td>
<td>21,600 (149)</td>
</tr>
<tr>
<td>Furnace Butt Welded, Continuous Welded</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>…</td>
<td>25,000 (172)</td>
<td>0.60</td>
<td>10,800 (74)</td>
</tr>
<tr>
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<td>25,000 (172)</td>
<td>0.60</td>
<td>10,800 (74)</td>
</tr>
<tr>
<td>Electric Resistance Welded and Electric Flash Welded</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>API 5L</td>
<td>A25</td>
<td>25,000 (172)</td>
<td>1.00</td>
<td>18,000 (124)</td>
</tr>
<tr>
<td>API 5L, ASTM A 53, ASTM A 135 A</td>
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<td>30,000 (207)</td>
<td>1.00</td>
<td>21,600 (149)</td>
</tr>
<tr>
<td>API 5L, ASTM A 53, ASTM A 135 B</td>
<td></td>
<td>35,000 (241)</td>
<td>1.00</td>
<td>25,200 (174)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X42</td>
<td>42,000 (289)</td>
<td>1.00</td>
<td>30,250 (208)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X46</td>
<td>46,000 (317)</td>
<td>1.00</td>
<td>33,100 (228)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X52</td>
<td>52,000 (358)</td>
<td>1.00</td>
<td>37,450 (258)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X56</td>
<td>56,000 (386)</td>
<td>1.00</td>
<td>40,300 (278)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X60</td>
<td>60,000 (413)</td>
<td>1.00</td>
<td>43,200 (297)</td>
</tr>
<tr>
<td>Type</td>
<td>Grade</td>
<td>Min. Yield Strength (ksi)</td>
<td>Joint Factor</td>
<td>Min. Allowable Stress (ksi)</td>
</tr>
<tr>
<td>---------------</td>
<td>-------</td>
<td>--------------------------</td>
<td>--------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>API 5L</td>
<td>X65</td>
<td>65,000 (448)</td>
<td>1.00</td>
<td>46,800 (323)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X70</td>
<td>70,000 (482)</td>
<td>1.00</td>
<td>50,400 (347)</td>
</tr>
<tr>
<td>API 5LU</td>
<td>U80</td>
<td>80,000 (551)</td>
<td>1.00</td>
<td>57,600 (397)</td>
</tr>
<tr>
<td>API 5LU</td>
<td>U100</td>
<td>100,000 (689)</td>
<td>1.00</td>
<td>72,000 (496)</td>
</tr>
</tbody>
</table>

**Electric Fusion Welded**

<table>
<thead>
<tr>
<th>Type</th>
<th>Grade</th>
<th>Min. Yield Strength (ksi)</th>
<th>Joint Factor</th>
<th>Min. Allowable Stress (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM A 134</td>
<td>A</td>
<td>30,000 (207)</td>
<td>0.80</td>
<td>17,300 (119)</td>
</tr>
<tr>
<td>ASTM A 139</td>
<td>B</td>
<td>35,000 (241)</td>
<td>0.80</td>
<td>20,150 (139)</td>
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</tbody>
</table>

**Submerged Arc Welded**

<table>
<thead>
<tr>
<th>Type</th>
<th>Grade</th>
<th>Min. Yield Strength (ksi)</th>
<th>Joint Factor</th>
<th>Min. Allowable Stress (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>API 5L</td>
<td>A</td>
<td>30,000 (207)</td>
<td>1.00</td>
<td>21,600 (149)</td>
</tr>
<tr>
<td>API 5L</td>
<td>B</td>
<td>35,000 (241)</td>
<td>1.00</td>
<td>25,200 (174)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X42</td>
<td>42,000 (289)</td>
<td>1.00</td>
<td>30,450 (208)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X46</td>
<td>46,000 (317)</td>
<td>1.00</td>
<td>33,100 (228)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X52</td>
<td>52,000 (358)</td>
<td>1.00</td>
<td>37,450 (258)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X56</td>
<td>56,000 (386)</td>
<td>1.00</td>
<td>40,300 (278)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X60</td>
<td>60,000 (413)</td>
<td>1.00</td>
<td>43,200 (298)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X65</td>
<td>65,000 (448)</td>
<td>1.00</td>
<td>46,800 (323)</td>
</tr>
<tr>
<td>API 5L</td>
<td>X70</td>
<td>70,000 (482)</td>
<td>1.00</td>
<td>50,400 (347)</td>
</tr>
<tr>
<td>ASTM A 381</td>
<td>Y35</td>
<td>35,000 (241)</td>
<td>1.00</td>
<td>25,200 (174)</td>
</tr>
<tr>
<td>ASTM A 381</td>
<td>Y42</td>
<td>42,000 (290)</td>
<td>1.00</td>
<td>30,250 (209)</td>
</tr>
<tr>
<td>ASTM A 381</td>
<td>Y46</td>
<td>46,000 (317)</td>
<td>1.00</td>
<td>33,100 (228)</td>
</tr>
<tr>
<td>ASTM A 381</td>
<td>Y48</td>
<td>48,000 (331)</td>
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<td>34,550 (238)</td>
</tr>
<tr>
<td>ASTM A 381</td>
<td>Y50</td>
<td>50,000 (345)</td>
<td>1.00</td>
<td>36,000 (248)</td>
</tr>
<tr>
<td>ASTM A 381</td>
<td>Y52</td>
<td>52,000 (358)</td>
<td>1.00</td>
<td>37,450 (258)</td>
</tr>
<tr>
<td>ASTM A 381</td>
<td>Y60</td>
<td>60,000 (413)</td>
<td>1.00</td>
<td>43,200 (298)</td>
</tr>
<tr>
<td>ASTM A 381</td>
<td>Y65</td>
<td>65,000 (448)</td>
<td>1.00</td>
<td>46,800 (323)</td>
</tr>
</tbody>
</table>

**GENERAL NOTES**

(a) Allowable stress values shown in this Table are equal to 0.72 $E$ (weld joint factor) x specific minimum yield strength of the pipe.
(b) Allowable stress values shown are for new pipe of known specification. Allowable stress values for new pipe of unknown specification, ASTM A 120 specification, or used (reclaimed) pipe shall be determined in accordance with section 6.2.3.1.
(c) For some Code computations, particularly with regard to branch connections [see section 6.4.3.1(d)(3)] and expansion, flexibility, structural attachments, supports and restraints (section 6.0, Part 5), the weld joint factor $E$ need not be considered.
(d) For specified minimum yield strength of other grades in approved specifications, refer to that particular specification.
(e) Allowable stress value for cold worked pipe subsequently heated to 600°F (300 °C) or higher (welding expected) shall be 75% of the value listed in the Table.
(f) Definitions for the various types of pipe are given in section 4.0.
(g) Metric stress levels are given in MPa (1 megapascal = 1 million pascals).
NOTE:

(1) See applicable plate specification for yield point and refer to section 6.2.3.1 for calculation of \( S \).
(2) Factor applies for Classes 12, 22, 32, 42, and 52 only.
(3) Radiography must be performed after heat treatment.
(4) Factor applies for classes 13, 23, 33, 43, and 53 only.

6.2.4.4 Wall Thickness and Defect Tolerances

Wall thickness tolerances and defect tolerances for pipe shall be as specified in applicable pipe specifications or dimensional standards included in this Code by reference in Appendix A.

Part 2 - PRESSURE DESIGN OF PIPING COMPONENTS

6.3 CRITERIA FOR PRESSURE DESIGN OF PIPING COMPONENTS

The design of piping components, considering the effects of pressure, shall be in accordance with section 6.4. In addition, the design shall provide for dynamic and weight effects include in section 6.1 and design criteria in section 6.2.
6.4 PRESSURE DESIGN OF COMPONENTS

6.4.1 Straight Pipe

6.4.1.1 General

The *nominal* wall thickness of straight sections of steel pipe shall be equal to or greater than \( t_n \) determined in accordance with the following equation.

\[
t_n = t + A
\]

The notations described below are used in the equations for the pressure design of straight pipe.

- \( t_n \) = nominal wall thickness satisfying requirements for pressure and allowances.
- \( t \) = pressure design wall thickness as calculated in mm (inches) in accordance with section 6.4.1.2 for internal pressure. As noted under section 6.4.3.1, in setting design factor, due consideration has been given to and allowance has been made for the underthickness tolerance and maximum allowable depth of imperfections provided for in the specifications approved by the Code.
- \( A \) = sum of allowances for threading and grooving as required under section 6.2.4.2, corrosion as required under section 6.2.4.1, and increase in wall thickness if used as protective measure under section 6.2.1
- \( P_i \) = internal design gauge pressure (see section 6.1.2.2), psi (bar)
- \( D \) = outside diameter of pipe, mm (in.)
- \( S \) = applicable allowable stress value, MPa (psi), in accordance with section 6.2.3.1(a), (b), (c), or (d)

6.4.1.2 Straight Pipe Under Internal Pressure

The internal pressure design wall thickness \( t \) of steel pipe shall be calculated by the following equation.

\[
t = \frac{P_i D}{2S}
\]

6.4.1.3 Straight Pipe Under External Pressure

Pipelines within the scope of this Code may be subject to conditions during construction and operation where the external pressure exceeds the internal pressure (vacuum within the pipe or pressure outside the pipe when submerged). The pipe wall selected shall provide adequate strength to prevent collapse, taking into consideration mechanical properties, variations in wall thickness permitted by material specifications, ellipticity (out-of-roundness), bending stresses, and external loads (see section 6.1.2.2).

6.4.2 Curved Segments of Pipe

Changes in direction may be made by bending the pipe in accordance with section 6.6.2.1. or installing factory made bends or elbows, in accordance with section 6.6.2.3.
### TABLE 2 - WELD JOINT FACTOR E

<table>
<thead>
<tr>
<th>Specification No.</th>
<th>Pipe Type [Note (1)]</th>
<th>Weld Joint Factor E</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM A 53</td>
<td>Seamless</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Electric resistance welded</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Furnace butt welded</td>
<td>0.60</td>
</tr>
<tr>
<td>ASTM A 106</td>
<td>Seamless</td>
<td>1.00</td>
</tr>
<tr>
<td>ASTM A 134</td>
<td>Electric fusion (arc) welded</td>
<td>0.80</td>
</tr>
<tr>
<td>ASTM A 135</td>
<td>Electric resistance welded</td>
<td>1.00</td>
</tr>
<tr>
<td>ASTM A 139</td>
<td>Electric fusion (arc) welded</td>
<td>0.80</td>
</tr>
<tr>
<td>ASTM A 381</td>
<td>Double submerged arc welded</td>
<td>1.00</td>
</tr>
<tr>
<td>ASTM A 671</td>
<td>Electric fusion welded</td>
<td>1.00 [Note (2), (3)]</td>
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<tr>
<td></td>
<td></td>
<td>0.80 [Note (4)]</td>
</tr>
<tr>
<td>ASTM A 672</td>
<td>Electric fusion welded</td>
<td>1.00 [Notes (2), (3)]</td>
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<tr>
<td></td>
<td></td>
<td>0.80 [Note (4)]</td>
</tr>
<tr>
<td>API 5L</td>
<td>Seamless</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Electric resistance welded</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Electric induction welded</td>
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<tr>
<td></td>
<td>Submerged arc welded</td>
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<tr>
<td></td>
<td>Furnace butt welded, continuous</td>
<td>0.60</td>
</tr>
<tr>
<td>API 5LU</td>
<td>Seamless</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Electric resistance welded</td>
<td>1.00</td>
</tr>
<tr>
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<td>Electric induction welded</td>
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</tr>
<tr>
<td></td>
<td>Submerged arc welded</td>
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<tr>
<td>Known</td>
<td>Known</td>
<td>Note (5)</td>
</tr>
<tr>
<td>Unknown</td>
<td>Seamless</td>
<td>1.00 [Note (6)]</td>
</tr>
<tr>
<td>Unknown</td>
<td>Electric resistance welded</td>
<td>1.00 [Note (6)]</td>
</tr>
<tr>
<td>Unknown</td>
<td>Electric fusion welded</td>
<td>0.80 [Note (6)]</td>
</tr>
<tr>
<td>Unknown</td>
<td>Over NPS 4</td>
<td>0.80 [Note (7)]</td>
</tr>
<tr>
<td>Unknown</td>
<td>NPS 4 and smaller</td>
<td>0.60 [Note (8)]</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Definitions for the various pipe types (weld joints) are given in section 4.0.
2. Factor applies for Classes 12, 22, 32, 42, and 52 only.
3. Radiography must be performed after heat treatment.
4. Factors apply for Classes, 13, 23, 33, 43, and 53 only.
5. Factors shown above apply for new or used (reclaimed) pipe if pipe specification and pipe type are known.
6. Factor applies for new or used pipe of unknown specification an ASTM A 120 if the type of weld joint is known.
7. Factor applies for new or used pipe of unknown specification and ASTM A 120 or the pipe over NPS 4 if type of joint is known.
8. Factor applies for new or used pipe of unknown specification and ASTM A 120 or for pipe NPS 4 and smaller if type of joint is Unknown.

#### 6.4.2.1 Pipe Bends

The wall thickness of pipe before bending shall be determined as for straight pipe in accordance with section 6.4.1. Bends shall meet the flattening limitations of section 9.1.7.1.
6.4.2.2 Elbows

a) The minimum metal thickness of flanged or threaded elbows shall not be less than specified for the pressures and temperatures in the applicable American National Standard or the MSS Standard Practice.

b) Steel butt welding elbows shall comply with ANSI B16.9, ANSI B16.28, or MSS SP-75 and shall have pressure and temperature ratings based on the same stress values as were used in establishing the pressure and temperature limitations for pipe of the same or equivalent materials.

6.4.3 Intersections

6.4.3.1 Branch Connections

Branch connections may be made by means of tees, crosses, integrally reinforced extruded outlet headers, or welded connections, and shall be designed in accordance with the following requirements.

a) Tees and Crosses

(1) The minimum metal thickness of flanged or threaded tees and crosses shall not be less than specified for the pressures and temperatures in the applicable American National Standard or MSS Standard Practice.

(2) Steel butt welding tees and crosses shall comply with ANSI B16.9 or MSS SP-75 and shall have pressure and temperature ratings based on the same stress value as were used in establishing the pressure and temperature limitations for pipe of the same or equivalent materials.

(3) Steel butt welding tees and crosses may be used for all ratios of design hoop stress to specified minimum yield strength of the adjoining header and branch pipe, providing they comply with (2) above.

b) Integrally Reinforced Extruded Outlet Headers

1) Integrally reinforced extruded outlet headers may be used for all ratios of branch diameter to header diameter and all ratios of design hoop stress to specified minimum yield strength of the joining header and branch pipe, provided they comply with (2) through (8) immediately following.

2) When the design meets the limitations on geometry contained herein, the rules established are valid and meet the intent of the Code. These rules over minimum requirements and are selected to assure satisfactory performance of extruded headers subjected to pressure. In addition, however, forces and moments are usually applied to the branch by such agencies as thermal expansion and contraction, by vibration, by dead weight of piping, valves and fittings, covering and contents, and by earth settlement. Consideration shall be given to the design of extruded header to withstand these forces and moments.

3) Definition

(a) An extruded outlet header is defined as a header in which the extruded lip at the outlet has a height above the surface of the header which is equal to or greater than the radius of curvature of the external contoured portion of the outlet, i.e., \( h_o = r_o \). See nomenclature and Fig. 2.

(b) These rules do not apply to any nozzle in which additional non-integral material is applied in the form of rings, pads, or saddles.

(c) These rules apply only to cases where the axis of the outlet intersects and is perpendicular to the axis of the header.

4) Notation. The notation used herein illustrated in Fig. 2. All dimensions are in mm (inches).

\[
\begin{align*}
  d & = \text{outside diameter of branch pipe} \\
  d_c & = \text{internal diameter of branch pipe}
\end{align*}
\]
D = outside diameter of header
Dc = internal diameter of header
Do = internal diameter of extruded outlet measured at the level of the outside surface of header.
h0 = height of the extruded lip. This must be equal to or greater than ro except as shown in (4)(b) below.
L = height of the reinforcement zone.

\[ L \geq 0.7 \sqrt{dT_o} \]

\( t_b \) = required thickness of the branch pipe according to the wall thickness equation in section 6.4.1.2
\( T_b \) = actual nominal wall thickness of branch
\( t_h \) = required thickness of the branch pipe according to the wall thickness equation in section 6.4.1.2

\( T_h \) = actual nominal wall thickness of header
\( T_o \) = finished thickness of extruded outlet measured at a height equal to \( r_o \) above the outside surface of the header
\( r_i \) = half-width of reinforcement zone (equal to Do)
\( r_o \) = radius of curvature of external contoured portion of outlet measured in the plane containing the axes of the header and branch. This is subject to the following limitations.

(a) *Minimum Radius.* This dimension shall not be less than 0.05d, except that on diameters larger than NPS 30 it need not exceed 38mm (1.50 in.).
Figure 2. Reinforced extruded outlets
## TABLE 3 - DESIGN CRITERIA FOR WELDED BRANCH CONNECTIONS

| Ratio of Design Hoop Stress to Specified Min. Yield Strength of the Header | Ratio of Diameter of Hole Cut for Branch Connection to Nominal Header Diameter |
|---|---|---|---|---|
| | 25% or less | More than 25% Through 50% | More Than 50% |
| 20% or less | (4) | (4) | (4) (5) |
| More than 20% Through 50% | (2) (3) | (2) | (1) |
| More than 50% | (2) (3) | (2) | (1) |

(b) **Maximum Radius.** For outlet pipe sizes NPS 8 and larger, this dimension shall not exceed \(0.10d_o + 0.50\text{in.} \) (13mm). For outlet pipe sizes less than NPS 8, this dimension shall not be greater than 1.25in. (32mm).

(c) When the external contour contains more than one radius, the radius of any arc sector of approximately 45 deg. shall meet the requirements of (a) and (b) above.

(d) Machining shall not be employed in order to meet the above requirements.

5) **Required Area.** The required area is defined as

\[
A = K(t_h D_o),
\]

where \(K\) shall be taken as follows:

- for \(d/D\) greater than 0.60, \(K = 1.00\);
- for \(d/D\) greater than 0.15 and not exceeding 0.20, \(K = 0.6 + 2/3 d/D\);
- for \(d/D\) equal to or less than 0.15, \(K = 0.70\).

The design must meet the criteria that the reinforcement area defined in (6) is not less than the required area.

6) **Reinforcement Area.** The reinforcement area shall be the sum of areas \(A_1 + A_2 + A_3\) as defined below

(a) **Area \(A_1\).** The area lying within the reinforcement zone resulting from any excess thickness available in the header wall, i.e.

\[
A_1 = D_o (T_h - t_h)
\]

(b) **Area \(A_2\).** The area lying within the reinforcement zone resulting from any excess thickness available in the branch pipe wall, i.e.

\[
Area A_2 = 2L T_b - t_b)
\]

(c) **Area \(A_3\).** The area lying within the reinforcement zone resulting from excess thickness available in the extruded outlet lip, i.e.

\[
Area A_3 = 2r_o (T_o - T_r)
\]

7) **Reinforcement of Multiple Openings.** The requirements outlined in section 6.4.3.1(e) shall be followed, except that the required area and reinforcement area shall be as given in (5) and (6) above.

8) The manufacturer shall be responsible for establishing and marking on the section containing extruded outlets, the design pressure and temperature, Established under provisions of this code and the manufacturer’s name or trademark.
c) **Welded Branch Connections.** Welded branch connections shall be shown in Figs. 3, 4, and 5. Design shall meet the minimum requirements listed in Table 3 and described by items (1), (2), (3), and (4). Where reinforcement is required, items (5) and (6) shall apply.

1) Smoothly contoured wrought tees or crosses of proven design or integrally reinforced extruded headers are preferred. When such tees, crosses, or headers are not used, the reinforcing member shall extend completely around the circumference of the header [see Fig. 3 for typical constructions]. The inside edges of the finished opening whenever possible shall be rounded to a 3mm (1/8 in.) radius. If the encircling member is thicker than the header and its ends are to be welded to the header, the ends shall be chamfered (at approximately 45 deg.) down to a thickness not in excess of the header thickness, and continuous fillet welds shall be made. Pads, partial saddles, or other types of localized reinforcements are prohibited.

2) The reinforcement member may be of the complete encirclement type [see Fig. 3], pad or saddle type [see Fig. 4], or welding outlet fitting type. Where attached to the header by fillet welding, the edges of the reinforcement member shall be chamfered (at approximately 45 deg.) down to a thickness not in excess of the header thickness. The diameter of the hole cut in the header pipe for a branch connection shall not exceed the outside diameter of the branch connection by more than 6mm (¼ in.).
GENERAL NOTE: If the encircling member for tee, sleeve, or saddle type is thicker than the header and its ends are to be welded to the header, the ends shall be chamfered (at approximately 45 deg.) down to a thickness not in excess of the header thickness.

Figure 3. Welded details for openings with complete encirclement types of reinforcement
$M$ = nominal wall thickness of pad reinforcement member
$M_b$ = nominal wall thickness of saddle at branch end
$M_h$ = nominal wall thickness of saddle at header end
$N$ = 1/16 in. (1.5 mm) (min.) 1/8 in. (3 mm) (max.) (unless back welded or backing strip used)
$T_b$ = nominal wall thickness of branch

$W_1$ (min.) = the smaller of the $T_b$, $M$, 3/8 in. (10 mm)
$W_1$ (max.) = approx. $T_b$
$W_2$ (min.) = the smaller of 0.7 $T_b$, 0.7 $M$, or 1/2 in. (13 mm)
$W_2$ (max.) = approx. $T_b$
$W_3$ (min.) = the smaller of 0.7 $T_b$, 0.7 $M$, or 1/2 in. (13 mm)
$W_3$ (max.) = the smaller of $T_b$, $M_b$, or 3/8 in. (10 mm)

**GENERAL NOTES**

All welds are to have qua leg dimensions and a minimum throat equal to 0.70 x leg dimension.

If the reinforcing member is thicker at its edges than the header, the edge shall be chamfered (at approximately 45 deg.) down to a thickness such that leg dimensions of the fillet weld shall be with the minimum and maximum dimensions specified above.

A hole shall be provided in reinforcement to reveal leakage in buried welds and to provide venting during welding and heat treatment [see section 6.4.3.1 (d)(8)].

**Figure 4.** Welding details for openings with localised type reinforcement

3) Reinforcement for branch connections with hole cut NPS 2 or smaller is not required [see Fig. 5 for typical details]; however, care shall be taken to provide suitable protection against vibrations and other external forces to which these small branch connections are frequently subjected.
4) Reinforcement of opening is not mandatory; however, reinforcement may be required for cases involving pressure over 7 bar (100 psi), thin wall pipe, or severe external loads.

5) If a reinforcement member is required, and the branch diameter is such that a localized type of reinforcement member would extend around more than half the circumference of the header, then a complete encirclement type of reinforcement member shall be used, regardless of the design hoop stress, or a smoothly contoured wrought steel tee or cross of proven design or extruded header may be used.

6) The reinforcement shall be designed in accordance with section 6.4.3.1(d).

d) Reinforcement of single openings

1) When welded branch connections are made to pipe in the form of single connection, or in a header or manifold as a series of connections, the design shall be adequate to control the stress levels in the pipe within safe limits. The construction shall take cognizance of the stresses in the remaining pipe wall due to the opening in the pipe or header, the shear stresses produced by the pressure acting on the area of the branch opening, and any external loading due to thermal movement, weight, vibration, etc., and shall meet the minimum requirements listed in Table 3. The following sections provide design rules based on the stress intensification created by the existence of a hole in an otherwise symmetrical section. External loadings, such as those due to thermal expansion or unsupported weight of connecting pipe, have not been evaluated. These factors should be given attention in unusual designs or under conditions of cyclic loading.

When pipe which has been cold worked to meet the specified minimum yield strength is used as a header containing single or multiple welded branch connections, stresses shall be in accordance with section 6.2.3.1(d).

2) The reinforcement required in the crotch section of a welded branch connection shall be determined by the rule that the metal area available for reinforcement shall be equal to or greater than the required cross-sectional area as defined in (3) below and in Fig. 6.

3) The required cross-sectional area \(A_R\) is defined as the product of \(d\) times \(t_h\): \[A_R = d \times t_h\]

Where
\(d\) = length of the finished opening in the header wall measured parallel to the axis of the header.
\(t_h\) = design header wall thickness required by section 6.4.1.2. For welded pipe, when the branch does not intersect the longitudinal or spiral weld of the header, the allowable stress value for seamless pipe of comparable grade may be used in determining \(t_h\) for the purpose of reinforcement calculations only. When the branch does intersect the longitudinal or spiral weld of the header, the allowable stress value \(S\) of the branch shall be used in calculating \(t_b\).

4) The area available for the reinforcement shall be the sum of:

(a) the cross-sectional area resulting from any excess thickness available in the header thickness (over the minimum required for the header as defined in section 6.4.1.2) and which lies within the reinforcement area as defined in section 6.4.3.1(d)(5) below;

(b) the cross-sectional area resulting from any excess thickness available in the branch wall thickness required for the branch and which lies within the reinforcement area as defined in section 6.4.3.1(d)(5) below:

(c) the cross-sectional area of all added reinforcing metal, including weld metal, which is welded to the header wall and lies within the reinforcement area as defined in section 6.4.3.1(d)(5) below.

5) The reinforcement area is shown in Fig. 5 and is defined as a rectangle whose length shall extend a distance \(d\) [see section 6.4.3.1(d)(3)] on each side of the transverse centerline of the finished opening and whose width
shall extend a distance of $2\frac{1}{2}$ times the thickness of the branch wall from the outside surface of the header or of the reinforcement if any.

GENERAL NOTE:
When a welding saddle is used, it shall be inserted over this type of connection. See fig. 4.

$T_h = \text{nominal thickness of header}$
$T_b = \text{nominal wall thickness of branch}$
$W_{(\text{min})} = \text{the smaller of the } T_h, M, 3/8 \text{ in. (10 mm)}$
$N = 1/16 \text{ in. (1.5 mm) (min.)} \, 1/8 \text{ in. (3 mm) (max.)} \; (\text{unless back welded or backing strip used})$

Figure 5. welding details for openings without reinforcement other than that in header and branch walls

“Area of reinforcement” enclosed by _______ line
Reinforcement area required $A_R = d t_h$
Area available as reinforcement $= A_1 + A_2 + A_3$
$A_1 = (T_h - t_h) d$
$A_2 = 2 (T_b - t_b) L$
$A_3 = \text{summation of area of all added reinforcement, including weld areas that lie within the “area of reinforcement”}$
$A_1 + A_2 + A_3 \text{ must be equal to or greater than } A_R$

Where
$T_h = \text{nominal thickness of header}$
The material of any added reinforcement shall have an allowable working stress at least equal to that of the header wall, except that material of lower allowable stresses for header and reinforcement material respectively.

The material used for ring or saddle reinforcement may be of specifications differing from those of the pipe, provided the cross-section area is made incorrect proportions to the relative strength of the pipe and reinforcement materials at the operating temperatures, and provide it has welding qualities comparable to those of the pipe. No credit will be taken for the additional strength of material having a higher strength than that of the part to be reinforced.

When rings or saddles are used which cover the weld between branch and header, a vent hole shall be provided in the ring or saddle to reveal leakages in the weld between branch and header and to provide venting holes shall be plugged during service to prevent crevice corrosion between pipe and reinforcing member, but no plugging material shall be used that would be capable of sustaining pressure with the crevice.

The use of ribs or gussets shall not be considered as contributing to reinforcement to the branch connection. This does not prohibit the use of ribs or gussets for purposes other than reinforcement, such as stiffening.

Branch connections attached at an angle less than 90 deg. to the header become progressively weaker as the angle becomes less. Any such design shall be given individual study, and sufficient reinforcement shall be provided to compensate for the inherent weakness of such construction. The use of encircling ribs to support the flat or reentering surfaces is permissible and may be included in the strength consideration. The designer is cautioned that stress concentrations near the ends of partial ribs, straps, or gussets may defeat their reinforcing value, and their use is not recommended.

e) Reinforcement of Multiple Openings

1) Two adjacent branches should preferably be spaced at such a distance that their individual effective areas of reinforcement do not overlap. When two or more adjacent branches are spaced at less than two times their average diameter (so that their effective areas of reinforcement overlap), the group of openings shall be reinforced in accordance with section 6.5.3.1(d). The reinforcing metal shall be added as a combined reinforcement, the strength of which shall equal the combined strengths of the reinforcement that would be required for the separate openings. In no case shall any portion of a cross section be considered to apply to more than one opening, or be evaluated more than once in a combined area.

2) When more than one adjacent openings are to be provided with a combined reinforcement, the minimum distance between centres of any two of these openings shall preferably be at least 1½ times their average diameter, and the area of reinforcement between them shall be at least equal to 50% of the total required for these two openings on the cross section being considered.
3) When two adjacent openings as considered under section 6.4.3.1(e)(2) have the distance between centres less than 1\(\frac{2}{3}\) times their average diameter, no credit for reinforcement shall be given for any of the metal between these two openings.

4) When pipe which has been cold worked to meet the specified minimum yield strength is used as a header containing single or multiple welded branch connections, stresses shall be in accordance with section 6.2.3.1(d).

5) Any number of closely spaced adjacent openings, in any arrangement, may be reinforced as if the group were treated as one assumed opening of a diameter enclosing all such openings.

6.4.3.2 Attachments

External and internal attachments to piping shall be designed so they will not cause flattening of the pipe, excessive localised bending stresses, or harmful thermal gradients in the pipe wall. See section 6.16.1 for design of pipe supporting elements.

6.4.4 Pressure Design of Flanges

6.4.4.1 General

a) The design of flanges manufactured in accordance with section 6.8.1 and the standards listed in Table 5 shall be considered suitable for use at the pressure-temperature ratings as set forth in section 6.2.2.1.

b) It is permissible to inside taper bore the hubs on welding neck flanges having dimensions complying with ANSI B16.5 when they are to be attached to thin wall pipe. It is recommended that the taper shall not be more abrupt than a ratio of 1:3 MSS SP-44, NPS 26, and larger “pipeline” flanges are designed for attachment to thin wall pipe and are preferred for this service.

c) Where conditions require the use of flanges other than those covered in section 6.8.1, the flanges shall be designed in accordance with Appendix II of Section VII, Division 1, of the ASME Boiler and Pressure Vessel Code.

d) Slip-on flanges of rectangular cross section shall be designed so that flange thickness is increased to hubbed slip-on flange covered by ANSI16.5, as determined by calculations made in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

6.4.5 Reducers

a) Reducer fittings manufactured in accordance with ANSI B16.5, ANSI B16.9, or MSS SP-75 shall have pressure-temperature ratings based on the same stress value as were used in establishing the pressure-temperature limitations for pipe of the same or equivalent material.

b) Smoothly contoured reducers fabricated to the same nominal wall thickness and of the same type of steel as the adjoining pipe shall be considered suitable for use at the pressure-temperature ratings of the adjoining pipe. Seam welds of fabricated reducers shall be inspected by radiography or other accepted nondestructive methods (visual inspection excepted).

c) Where appropriate, changes in diameter may be accomplished by elbows, reducing outlet tees, or valves.

6.4.6 Pressure Design of other Pressure Containing Components

Pressure containing components which are not covered by the standards listed on Table 4 or 8.1.1 and for which design equations or procedures are not given herein may be used where the design of similarly shaped, proportioned, and size components has been proven satisfactory by successful performance under comparable service conditions.
(Interpolation may be made between similarly shaped proved components with small differences in size or proportion.) In the absence of such service experience, the pressure design shall be based on an analysis consistent with the general design philosophy embodied in this Code, and substantiated by at least one of the following:

a) Proof tests (as are described in UG-101 of section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code);

b) Experimental stress analysis (such as described in Appendix 6 of Section VIII, Division 2, of the ASME Boiler and Pressure Vessel Code);

c) Engineering calculations.

Part 3 - DESIGN APPLICATIONS OF PIPING COMPONENTS SELECTION AND LIMITATIONS

6.5 PIPE

6.5.1 Metallic Pipe

6.5.1.1 Ferrous Pipe

a) New pipe of the specifications listed in Table 4 may be used in accordance with the design equation of section 6.4.1.2 subject to the testing requirements of sections 10.2.2.1, 10.2.2.2 and 10.2.2.2.

b) Used pipe of known specification listed in Table 4 may be used in accordance with the design equation of section 6.4.1.2 subject to the testing requirements of sections 10.2.2.1, 10.2.3.1, 10.2.3.3 and 10.2.3.4.

c) New or used pipe of unknown or ASTM A 120 specification may be used in accordance with the design equation in section 6.4.1.2 with an allowable stress value as specified in section 6.2.3.1(c) and subject to the testing requirements of sections 10.2.2.1, 10.2.2.2, 10.2.3.1, 10.2.3.3, 10.2.3.4, and 10.2.3.5, if 165 MPa (24,000 psi) yield strength is used to establish an allowable stress value; or section 10.2.2.1, and 10.2.3.1 through 10.2.3.7 inclusive, if a yield strength above 165 MPa (24,000 psi) is used to establish an allowable stress value.

d) Pipe which has been cold worked in order to meet the specified minimum yield strength and is subsequently heated to 300ºC (600ºF) or higher (welding excepted) shall be limited to a stress value as noted in section 6.2.3.1(d).

e) Coated or Lined Pipe. External or internal coatings or linings of cement, plastics, or other materials may be used on steel pipe conforming to the requirements of this Code. These coatings or linings shall not be considered to add strength.

6.6 FITTINGS, ELBOWS, BENDS, AND INTERSECTIONS

6.6.1 Fittings

6.6.1.1 General

a) Steel Butt Welding Fittings. When steel butt welding fittings [see sections. 6.4.2.2(b), 6.4.3.1(a)(2), and 6.4.3.1(a)(3)] are used they shall comply with ANSI B 16.9, ANSI B16.28, or MSS SP-75.

b) Steel Flanged Fittings. When steel flanged fittings [see sections. 6.4.3.1(a)(1) and 6.4.4.1] are used, they shall comply with ANSI B16.5.

c) Fitting Exceeding Scope of Standard Sizes. Fittings exceeding scope of standard sizes or otherwise departing from dimensions listed in the standards referred to in section 6.6.1.1(a) or 6.6.1.1(b) may be used, provided the designs meet the requirements of sections. 6.3 and 6.4.

6.6.2 Bends, Mitres, and Elbows
6.6.2.1 Bends Made From Pipe

a) Bends may be made by bending the pipe when they are designed in accordance with section 6.4.2.1 and made in accordance with section 9.1.7.1.

b) Except as permitted under section 6.6.2.1(c), the minimum radius of field cold bends shall be as follows:

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Minimum Radius of Bend in Pipe Diameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS 12 and smaller</td>
<td>18D</td>
</tr>
<tr>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>18</td>
<td>27</td>
</tr>
<tr>
<td>NPS 20 and larger</td>
<td>30</td>
</tr>
</tbody>
</table>

In some cases, thin wall pipe will require the use of an internal mandrel when being bent to the minimum radii tabulated above.

c) Bends may be made by bending the pipe in sizes NPS 14 and larger to a minimum radius of 18D; however, bending pipe to radii approaching 18D that will meet requirements in section 9.1.7.1(b) will be dependent upon wall thickness, ductility, ratio of pipe diameter to wall thickness, use of bending mandrel, and skill of bending crew. Test bends shall be made to determine that the field bending procedure used produces bends meeting the requirements of section 9.1.7.1(b) and that the wall thickness after bending is not less than the minimum permitted by the pipe specification.

6.6.2.2 Mitred Bends

In systems intended to operate at a hoop stress of more than 20% of the specified minimum yield strength of the pipe, mitre bends are prohibited. Bends not exceeding 12½ degrees may be used in systems operated at a hoop stress of 20% or less of the specified minimum yield strength of the pipe, and the minimum distance, between mitres measure at the crotch shall not be less than one pipe diameter. When the system is to be operated at a hoop stress of less than 10% of the specified minimum yield strength of the pipe, the restriction to 12½ degrees maximum mitre and distance between mitres will not apply. Deflections caused by misalignment up to 3 degrees are not considered mitre bends.

6.6.2.3 Factory Made Bends and Elbows

a) Factory made bends and factory made wrought steel elbows may be used provided they meet the design requirements of sections 6.4.2.1 and 6.4.2.2 and the construction requirements of section 9.1.7.3 such fittings shall have approximately the same mechanical properties and chemical composition as the pipe to which they are welded.

b) If the factory made elbows are used in cross-country lines, care should be taken to allow for passage of pipeline scrapers.

6.6.2.4 Wrinkle Bends. Wrinkle bends shall not be used.

6.6.3 Couplings

Cast, malleable, or wrought iron threaded couplings are prohibited.

6.6.4 Reductions

6.6.4.1 Reducers
Reductions in line size may be made by the use of smoothly contoured reducers selected in accordance with ANSI B16.5, ANSI B16.9, or MSS SP-75 or designed as provided in section 6.4.6.

6.6.4.2 Orange Peel Swages

Orange peel swages are prohibited in systems operating at hoop stresses of more than 20% of the specified minimum yield strength of the pipe.

6.6.5 Intersections

Intersection fittings are welded branch connections are permitted within the limitations listed in section 6.6.1 (see 6.4.3 for design).

6.6.6 Closures

6.6.6.1 Quick Opening Closures

A quick opening closure is a pressure containing component (see section 6.4.7) used for repeated access to the interior of a piping system. It is not the intent of this Code to impose the requirements of a specific design method on the designer or manufacturer of a quick opening closure.

Quick opening closures used for pressure containment under this Code shall have pressure and temperature ratings equal to or in excess of the design requirements of the piping system to which they are attached. See sections 6.1.2.1 and 6.2.2.

Quick opening closures shall be equipped with safety locking devices in compliance with Section VIII, Division 1, UG-35(b) or the ASME Boiler and Pressure Vessel Code.

Weld end preparation shall be in accordance with section 9.18.6.

6.6.6.2 Closure Fittings

Closure fittings commonly referred to as “weld caps” shall be designed and manufactured in accordance with ANSI B16.9 or MSS SP-75.

6.6.6.3 Closure Heads

Closure heads such as flat, ellipsoidal (other than in section 6.6.2.2 above), spherical, or conical heads are allowed for use under this Code. Such items shall be designed in accordance with Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code. The maximum allowable stresses for materials used in these closure heads shall be established under the provisions of section 6.2.3.

If the welds are used in the construction of these heads, they shall be 100% radiographically inspected in accordance with the provisions of Section VIII, Division 1.

Closure heads shall have pressure and temperature ratings equal to or in excess of the requirement of section 6.1.2.1. It is not the intent of this Code to necessarily extend the design requirements of Section VIII, Division 1, to other components in which closure heads are part of a complete assembly.

6.6.6.4 Fabricated Closures

Orange peel bull plugs are prohibited on systems operating at a hoop stress more than 20% of the specified minimum yield strength of the pipe. Fishtails and flat closures are permitted for NPS 3 pipe and smaller, operating at less than 7 bar (100 psi). Fishtails on pipe larger than NPS 3 are prohibited.

6.6.6.5 Bolted Blind Flange Closures
Bolted blind flange closures shall conform to section 6.8.

6.7 VALVES

6.7.1 General

a) Steel valves conforming to standards and specifications listed in Tables 4 and 5 may be used. These valves may contain certain cast, malleable, or wrought iron parts as provided for in API 6D.

b) Cast iron valves conforming to standards and specifications listed in Tables 4 and 5 may be used for pressures not to exceed 17 bar (250 psi). Care shall be exercised to prevent excessive mechanical loadings (see section 6.8.5.4).

c) Working pressure ratings of the steel parts of steel valves are applicable within the temperature limitations of -30°C (-20°F) to 120°C (250°F) (see section 6.1.3.1), where resilient, rubber like, or plastic materials are used for sealing, they shall be capable of withstanding the fluid, pressures, and temperatures specified for the piping system.

6.7.2 Special Values

Special valves not listed in Tables 4 and 5 shall be permitted, provided that their design is of at least equal strength and tightness and they are capable of withstanding the same test requirements as covered in these standards, and structural features satisfy the material specification and test procedures of valves in similar service set forth in the listed standards.

6.8 FLANGES, FACINGS, GASKETS, AND BOLTING

6.8.1 Flanges

6.8.1.1 General

a) Flanged connections shall conform to the requirements of sections 6.8.1, 6.8.3, 6.8.4, and 6.8.5.

b) Steel Flanges within Scope of Standard Sizes. Welding neck, slip-on, threaded, and lapped companion flanges, reducing flanges, blind flanges, and flanges cast or forged integral with pipe, fittings, or valves, conforming to ANSI B16.5 or MSS SP-44, are permitted in the sizes listed in these standards and for the pressure-temperature ratings shown in section 6.2.2.1. The bore of welding neck flanges should correspond to the inside diameter of the pipe with which they are to be used. See section 6.4.4.1 for design.

c) Cast Iron Flanges Within Scope of Standard Sizes. Cast iron flanges are prohibited, except those which are an integral part of cast iron valves, pressure vessels, and other equipment and proprietary items [see section 6.7.1(b) and 7.1.2.3(b)].

d) Flanges Exceeding Scope of Standard Sizes. Flanges exceeding scope of standard sizes or otherwise departing from dimensions listed in ANSI B16.5 or MSS SP-44 may be used provided they are designed in accordance with section 6.4.4.1.

e) Flanges of Rectangular Cross Section. Slip-on flanges of rectangular cross section may be used provided they are designed in accordance with section 6.4.4.1(d).

6.8.2 Flanges Facings

6.8.2.1 General

a) Standard Facings. Steel or cast iron flanges shall have contact faces in accordance with ANSI B16.5 or MSS SP-6.
b) **Special Facings.** Special facings are permissible provided they are capable of withstanding the same tests as those in ANSI B16.5. See section 6.8.5.4 for bolting steel to cast iron flanges.

### 6.8.3 Gaskets

#### 6.8.3.1 General

Gaskets shall be made of materials which are not injuriously affected by the fluid in the piping system, and shall be capable of withstanding the pressures and temperatures to which they will be subjected to service.

#### 6.8.3.2 Standard Gaskets

a) Gaskets conforming to ANSI B16.20 or to ANSI B16.21 may be used.

b) Metallic gaskets other than ring type or spirally wound metal asbestos shall not be used with ANSI class 150 or lighter flanges.

c) The use of metal or metal jacketed asbestos (either plain or corrugated) is not limited [except as provided in section 6.8.4.2(b)] as to pressure, provided that the gasket material is suitable for the service temperature. These types of gaskets are recommended for use with the small male and female or the small tongue and groove facings. They may also be used with steel flanges with any of the following facings: lapped, large male and female, large tongue and groove, or raised face.

d) Asbestos composition gaskets may be used as permitted in ANSI B16.5. This type of gasket may be used with any of the various flange facings except small male and female, or small tongue and groove.

e) Rings for ring joints shall be dimensions established in ANSI B16.20. The materials for these rings shall be suitable for the service conditions encountered and shall be softer than the flanges.

#### 6.8.3.3 Special Gaskets

Special gaskets, including insulating gaskets, may be used provided they are suitable for the temperatures, pressures, fluids, and other conditions to which they may be subjected.

### 6.8.4 Bolting

#### 6.8.4.1 General

a) Bolts or stud bolts shall extend completely through the nuts.

b) Nuts shall conform with ASTM A 194 or A 325, except that A 307 Grade B nuts may be used on ANSI Class d150 and ANSI Class 300 flanges.

#### 6.8.4.2 Bolting for Steel Flanges

Bolting shall conform to ANSI B16.5.

#### 6.8.4.3 Bolting for Insulating Flanges

For insulating flanges, 3mm (¹/8 in.) undersize bolting may be used provided that alloy steel bolting material in accordance with ASTM A 193 or A 354 is used.

#### 6.8.4.4 Bolting Steel to Cast Iron Flanges

When bolting Class 150 steel flanges to Class 125 cast iron flanges, heat treated carbon steel or alloy steel bolting (ASTM A 193) may be used only when both flanges are flat face and the gasket is full face, otherwise, the bolting shall have a maximum tensile strength no greater than the maximum tensile strength of ASTM A 307 Grade B. When bolting Class 300 steel flanges to Class 250 cast iron flanges, the bolting shall have a maximum tensile strength of ASTM A 307 Grade B. Good practice indicates that the flange should be flat faced.

#### 6.8.4.5 Bolting for Special Flanges

For flanges designed in accordance with section 6.4.4.1 [see sections.
6.8.1.1(d) and 6.8.1.1(e)], bolting shall conform to the applicable section of Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code.

6.9 USED PIPING COMPONENTS AND EQUIPMENT

Used piping components such as fittings, elbows, bends, intersections, couplings, reducers, closures, flanges, valves, and equipment may be re-used. [Re-use of pipe is covered by section 6.5.1.1(b).] However, such components and equipment shall be cleaned and examined; reconditioned, if necessary, to insure that they meet all requirements for the intended service; and sound and free of defects.

In addition, reuse shall be contingent on identification of the specification under which the item was originally produced. Where the specification cannot be identified, use shall be restricted to a maximum allowable operating pressure based on yield strength of 165 MPa (24,000 psi) or less.

Part 4 - SELECTION AND LIMITATION OF PIPING JOINTS

6.10 WELDED JOINTS

6.10.1 Butt Welds

Butt welded joints shall be in accordance with clause 9.0.

6.11 FLANGED JOINTS

6.11.1 General

Flanged joints shall meet the requirements of section 6.8.

6.12 THREADED JOINTS

6.12.1 General

All external pipe threads on piping components shall be taper pipe threads. They shall be line pipe threads in accordance with API 5B, or NPT threads in accordance with ANSI/ASME B1.20.1. All internal pipe threads on piping components shall be taper pipe threads, except for sizes NPS 2 and smaller with design gauge pressures not exceeding 10 bar (150 psi), in which case straight threads may be used.

Least nominal wall thickness for threaded pipe shall be standard wall (see ANSI/ASME B36.10M).

6.13 SLEEVE, COUPLED, AND OTHER PATENTED JOINTS

6.13.1 General

Steel connectors and swivels complying with API 6D may be used. Sleeve, coupled, and other patented joints except as limited in section 7.12.3(b), may be used provided:

a) a prototype joint has been subject to proof tests to determine the safety of the joints under simulated service conditions. When vibration, fatigue, cyclic conditions, low temperature, thermal expansion, or other severe conditions are anticipate, the applicable conditions shall be incorporated in the tests.

b) adequate provision is made to prevent separation of the joint and to prevent longitudinal or lateral movement beyond the limits provided for in the joining member.

Part 5 - EXPANSION, FLEXIBILITY, STRUCTURAL ATTACHMENTS, SUPPORTS AND RESTRAINTS
6.14 EXPANSION AND FLEXIBILITY

6.14.1 General

a) This Code is applicable to both above ground and buried piping and covers all classes of materials permitted by this Code. Formal calculations shall be required where reasonable doubt exists as to the adequate flexibility of the piping.

b) Piping shall be designed to have sufficient flexibility to prevent expansion or contraction from causing excessive stresses in the piping materials, excessive bending moments at joints, or excessive forces or moments at points of connection to equipment or at anchorage or guide points. Allowable forces and moments on equipment may be less than for the connected piping.

c) Expansion calculations are necessary for buried lines if significant temperature changes are expected, such as when the line is to carry a heated oil. Thermal expansion of buried lines may cause movement at points where the line terminates, changes in direction, or changes in size. Unless such movements are restrained by suitable anchors, the necessary flexibility shall be provided.

d) Expansion, of aboveground lines may be prevented by anchoring them so that longitudinal expansion, or contraction, due to thermal and pressure changes is absorbed by direct axial compression or tension of the pipe in the same way as for buried piping. In addition, however, beam bending stresses shall be included and the possible elastic instability of the pipe, and its supports, due to longitudinal compressive forces shall be considered.

6.14.2 Flexibility

6.14.2.1 Means of Providing Flexibility

If expansion is not absorbed by direct axial compression of the pipe, flexibility shall be provided by the use of bends, loops, or offsets; or provision shall be made to absorb thermal strains by expansion joints or couplings of the slip joint, ball joint, or bellows type. If expansion joints are used, anchors or ties of sufficient strength and rigidity shall be installed to provide for end forces due to fluid pressure and other causes.

6.14.3 Properties

6.14.3.1 Coefficient of Thermal Expansion

The linear coefficient of thermal expansion for carbon and low alloy high tensile steel may be taken as 11.7 X 10^-6 mm/mm/°C for temperatures up to 120°C (6.5 X 10^-6 in/in/°F for temperatures up to 250°F).

6.14.3.2 Moduli of Elasticity

Flexibility calculations shall be based on the modulus of elasticity at ambient temperature.

6.14.3.3 Poisson’s Ratio

Poisson’s ratio shall be taken as 0.3 for steel.

6.14.3.4 Stress Values

a) General

These are fundamental differences in loading conditions for the buried, or similarly restrained, portions of the piping and the above ground portions not subject to substantial axial restraint. Therefore, different limits on allowable longitudinal expansion stresses are necessary.

b) Restrained Lines
The net longitudinal compressive stress due to the combined effects of temperature rise and fluid pressure shall be computed from the equation:

\[ S_L = Ea(T_2 - T_1) - \Psi S_h \]

Where

- \( S_L \) = Longitudinal compression stress, MPa (psi)
- \( S_h \) = hoop stress due to fluid pressure, MPa (psi)
- \( T_1 \) = Temperature at time of installation, °C (°F)
- \( T_2 \) = Maximum or minimum operating temperature, °C (°F)
- \( E \) = Modulus of elasticity of steel, MPa (psi)
- \( a \) = Linear coefficient of thermal expansion mm/mm/°C (in./in./°F)
- \( \Psi \) = Poisson’s ratio = 0.30 for steel

Note that the net longitudinal stress becomes compressive for moderate increases of \( T_2 \) and that according to the commonly used maximum shear theory of failure, this compressive stress adds directly to the hoop stress available to cause yielding. This equivalent tensile stress shall not be allowed to exceed 90% of the specified minimum yield strength of the pipe, calculated for nominal pipe wall thickness. Beam bending stresses shall be included in the longitudinal stress for those portions of the strained line which are supported above ground.

c) Unrestrained Lines

Stresses due to expansion for those portions of the piping without substantial axial restraint shall be combined in accordance with the following equation:

\[ S_E = \sqrt{S_h^2 + 4S_T^2} \]

where

- \( S_E \) = stress due to expansion
- \( S_h \) = \( \frac{2\Psi M_i}{Z} \)
- \( S_T \) = \( \frac{i_i M_i + i_o M_o}{Z} \)
- \( Z \) = section modulus of pipe, cm^3 (in.³)
- \( M_i \) = bending moment in plane of member (for members having significant orientation, such as elbows or tees; for the latter the moments in the header and branch portions are to be considered separately), N·m (in.-lb)
- \( M_o \) = bending moment out of, or transverse to, plane of member, N·m (in.-lb)
- \( M_t \) = torsional moment, N·m (in.-lb)
- \( i_i \) = stress intensification factor under bending in plane of member [from fig. 7]
- \( i_o \) = stress intensification factor under bending out of, or transverse to, plane of member [from fig. 7]
- \( Z \) = section modulus of pipe, cm^3 (in.³)

The maximum computed expansion stress range – \( S_E \) without regard to fluid pressure stress based on 100% of the expansion, with modulus of elasticity for the cold condition – shall not exceed allowable stress range \( S_A \) where \( S_A = 0.72 \) of specified minimum yield strength of the pipe.

The sum of the longitudinal stresses due to pressure, weight and other sustained external loadings shall not exceed 0.75 \( S_A \).

The sum of the longitudinal stresses produced by pressure, live and dead loads, and those produced by occasional loads such as wind or earthquake, shall not exceed 80% of the specified minimum yield strength of the pipe. It is not
necessary to consider wind and earthquake as occurring concurrently.

As noted in section 6.2.3.3 (b) stresses due to test conditions are not subject to the limitations of section 6.2.3. It is not necessary to consider other occasional loads, such as wind and earthquake, as occurring concurrently with the live, dead and test loads existing at the time of test.

6.14.4 Analysis

6.14.4.1 Basic Assumptions and Requirements

a) The effect of restraints, such as support friction, branch connections, lateral interferences, etc, shall be considered in the stress calculations.

<table>
<thead>
<tr>
<th>Description</th>
<th>Flexibility Factor $k$</th>
<th>Stress Intensification Factor $I_j$</th>
<th>Flexibility Characteristic $h$</th>
<th>Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding elbow, 3,4,5,6,7</td>
<td></td>
<td>$\frac{1.65}{h}$</td>
<td>$\frac{0.9}{h^{2/3}}$</td>
<td></td>
</tr>
<tr>
<td>or pipe bend</td>
<td></td>
<td>$\frac{0.75}{h^{2/3}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closely spaced miter bend, 3,4,5,6</td>
<td></td>
<td>$\frac{0.9}{h^{2/3}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$s &lt; r(1 + \tan \theta)$</td>
<td></td>
<td>$\frac{0.75}{h^{2/3}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Widely spaced miter bend, 3,4,5,6</td>
<td></td>
<td>$\frac{0.9}{h^{2/3}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$s \geq r(1 + \tan \theta)$</td>
<td></td>
<td>$\frac{0.75}{h^{2/3}}$</td>
<td>$\frac{1 + \cot \theta}{2}$</td>
<td></td>
</tr>
<tr>
<td>Welding tee, 3,4</td>
<td>1</td>
<td>$0.75/\rho + 0.25$</td>
<td>$0.9$</td>
<td></td>
</tr>
<tr>
<td>per ANSI B16.9</td>
<td></td>
<td>$\frac{h^{2/3}}{}$</td>
<td>$4.4 \frac{r}{t}$</td>
<td></td>
</tr>
<tr>
<td>Reinforced tee, 3,4,6</td>
<td>1</td>
<td>$0.75/\rho + 0.25$</td>
<td>$0.9$</td>
<td></td>
</tr>
<tr>
<td>with pad or saddle</td>
<td></td>
<td>$\frac{h^{2/3}}{}$</td>
<td>$\frac{(r + 1/2.7)^{5/2}}{r^{5/2}}$</td>
<td></td>
</tr>
<tr>
<td>Unreinforced fabricated tee, 3,4</td>
<td>1</td>
<td>$0.75/\rho + 0.25$</td>
<td>$0.9$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\frac{h^{2/3}}{}$</td>
<td>$\frac{r}{t}$</td>
<td></td>
</tr>
</tbody>
</table>
### Figure 7. Flexibility factor $k$ and stress intensification factor $i$

<table>
<thead>
<tr>
<th>Description</th>
<th>Flexibility Factor $k$</th>
<th>Stress Intensification Factor $i$</th>
<th>Flexibility Characteristic $h$</th>
<th>Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butt welded joint, reducer, or welding neck flange</td>
<td>1</td>
<td>1.0</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Double welded slip-on flange</td>
<td>1</td>
<td>1.2</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Filet welded joint (single welded), or single welded slip-on flange</td>
<td>1</td>
<td>1.3</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Lapped flange (with ANSI B 16.9 lap-joint stub)</td>
<td>1</td>
<td>1.6</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Threaded pipe joint, or threaded flange</td>
<td>1</td>
<td>2.3</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Corrugated straight pipe, or corrugated or creased bend</td>
<td>5</td>
<td>2.5</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Notes:

(1) In-plane.
(2) Out-of-plane.
(3) For fitting and miter bends, the flexibility factors \( k \) and stress intensification factors \( i \) in the Table apply to bending in any plane and shall not be less than one; factors for torsion equal unity. Both factors apply over the effective arc length (shown by heavy centrelines in the sketches) for curved and miter elbows, and to the intersection point for tees.

(4) The values of \( k \) and \( i \) can be read directly from Chart A by entering with the characteristics \( h \) computed from the equations given, where

\[
R = \text{bend radius of welding elbow or pipe bend, mm (in.)}
\]

\[
T = \text{pad or saddle thickness, mm (in.)}
\]

\[
r = \text{mean radius of matching pipe, mm (in.)}
\]

\[
s = \text{miter spacing at centreline}
\]

\( t = \) nominal wall thickness of: part itself, for elbows and curved or miter bends; matching pipe, for welding tees; run or header, for fabricated tees (provided that if thickness is greater than that of matching pipe, increased thickness must be maintained for at least one run O.D to each side of the branch O.D).

\( \beta = \) one-half angle between adjacent miter axes, deg.

(5) Where flanges are attached to one or both ends, the values of \( k \) and \( i \) in the Table shall be corrected by the factors \( C_1 \) given below, which can be read directly from Chart B, entering with the computed \( h \): one end flanged, \( h^{1/6} = 1 \); both ends flanged, \( h^{1/3} = 1 \).

(6) The engineer is cautioned that cast but welding may have considerably heavier walls than that of the pipe with which they are used. Large errors may be introduced unless the effect of these greater thicknesses is considered.

(7) In large diameter thin wall elbows and bends, pressure can significantly affect the magnitude of flexibility and stress intensification factors. To correct values obtained from table for the pressure effect, divide:

Flexibility factor \( k \) by \( 1 + \frac{P}{E_c} \frac{r^2}{t^3} \)

Stress intensification factor \( i \) by \( 1 + \frac{3.25P}{E_c} \frac{r^2}{t^3} \)

Where:

\( E_c = \) cold modulus of elasticity

\( P = \) gauge pressure

(8) Also includes single miter joint.

(9) When \( T > 1.5t \), use \( h = 4.05t/r \).

(10) Factors shown apply to bending; flexibility factor for torsion equals 0.9.

Figure 7. Flexibility factor \( k \) and stress intensification factor \( i \) (cont’d)
b) Calculations shall take into account stress intensification factors found to exist in components other than plain straight pipe. Credit may be taken for extra flexibility of such components. In the absence of more directly applicable data, the flexibility factors and stresses intensification factors shown in fig. 7 may be used.

c) Nominal dimensions of pipe and fittings shall be used in flexibility calculations.
d) Calculations of pipe stresses in loops, bends and offsets shall be based on the total range from minimum to maximum temperature normally expected, regardless of whether piping is cold sprung or not. In addition to expansion of the line itself, the linear and angular movements of the equipment to which it is attached shall be considered.

e) Calculations of thermal forces and moments on anchors and equipment such as pumps, meters and heat exchangers shall be based on the difference between installation temperature and minimum or maximum anticipated operating temperature, whichever is greater.

6.15 LOADS OF PIPE SUPPORTING ELEMENTS

6.15.1 General

The forces and moments transmitted to connected equipment, such as valves, strainers, tanks, pressure vessels and pumping machinery shall be kept within safe limits.

6.16 DESIGN OF PIPE SUPPORTING ELEMENTS

6.16.1 Supports, Braces and Anchors

a) Supports shall be designed to support the pipe without causing excessive local stresses in the pipe and without imposing excessive axial or lateral friction forces that might prevent the desired freedom of movement.

b) Braces and damping devices may occasionally be required to prevent vibration of piping.

c) All attachments to the pipe shall be designed to minimize the added stresses in the pipe wall because of the attachment. Nonintegral attachments, such as pipe clamps and ring girders, are preferred where they will fulfill the supporting or anchoring functions.

d) If pipe is designed to operate at or close to its allowable stress, all connections welded to the pipe shall be made to a separate cylindrical member which completely encircles the pipe, and this encircling member shall be welded to the pipe by continuous circumferential welds.

e) The applicable sections of MSS SP-58 for materials and design of pipe hangers and supports and of MSS SP-69 for their selection and application may be used.

PART 6 - AUXILIARY AND OTHER SPECIFIC PIPING

6.17 DESIGN REQUIREMENTS

6.17.1 Instrument and Other Auxiliary Liquid Petroleum or Liquid Anhydrous Ammonia Piping

All instrument and other auxiliary piping connected to primary piping and which operates at a gauge pressure exceeding 1 bar (15 psi) shall be constructed in accordance with the provisions of this Code.

6.17.2 Pressure Disposal Piping

Pressure disposal or relief piping between pressure origin point and relief device shall be in accordance with this Code.

6.17.2.1 A full area stop valve may be installed between origin point and relief device providing such valve can be locked or sealed in the open position.

6.17.2.2 Disposal piping from relief device shall be connected to a proper disposal facility, which may be a flare stack, suitable pit, sump, or tank. This disposal piping shall have no valve between relief device and disposal facility unless
such valve can be locked or sealed in the open position.

7.0 MATERIALS

7.1 MATERIALS – GENERAL REQUIREMENTS

7.1.1 Acceptable Materials and Specifications

The materials used shall conform to the specifications listed in Table 4. Except as otherwise provided for in this Code, materials which do not conform to a listed specification or standard shall be qualified for use by application to the Zambia Bureau of Standards. Complete information shall be supplied to the Bureau and approval shall be obtained before the material may be used.

7.1.2 Limitations on Materials

7.1.2.1 General

a) The designer shall give consideration to the significance of temperature on the performance of the material.

b) Selection of material to resist deterioration in service is not within the scope of this Scope. It is the designer’s responsibility to select materials suitable for the fluid service under the intended operating conditions.

7.1.2.2 Steel

Steels for pipe are shown in Table 4.

7.1.2.3 Cast, Malleable and Wrought Iron

a) Cast, malleable and wrought iron shall not be used for pressure containing parts except as provided in sections 6.7.1(a), 6.7.1(b), and 7.1.2.3(b).

b) Cast, Malleable and wrought iron are acceptable in pressure vessels and other equipment noted in section 2.3(b) and in proprietary items (see section 2.3(g), except that pressure containing parts shall be limited to pressures not exceeding 7 bar (250 psi)

7.2 MATERIALS APPLIED TO MISCELLANEOUS PARTS

7.2.1 Gaskets

Limitations on gasket material are covered in section 6.8.4

7.2.2 Bolting

Limitations on bolting materials are covered in section 6.8.5
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<td>Electric-Fusion-Welded Steel Pipe for High-Pressure Service at Moderate Temperatures</td>
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<td>Pipeline Valves, End Closures, Connectors and Swivels</td>
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<td>Class 150, Corrosion Resistant Gate Valves</td>
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<td>Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components</td>
<td>MSS SP-55</td>
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<td>Specification For High Test Wrought Welding Fittings</td>
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<td>Bolting</td>
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<tr>
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<td>Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service</td>
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<td>Carbon Steel Externally Threaded Standard Fasteners</td>
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<td>High-Strength Bolts for Structural Steel Joints</td>
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<tr>
<td>Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners</td>
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<tr>
<td>Quenched and Tempered Steel Bolts and Studs</td>
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<tr>
<td>Heat Treated Steel Structural Bolts, 1035 MPa (150 ksi) Minimum Tensile Strength</td>
<td>ASTM A 490</td>
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<td>Structural Materials</td>
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<tr>
<td>General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use</td>
<td>ASTM A 6</td>
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</table>
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ASTM A 20
General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought and Cold-Finished
ASTM A 29
Structural Steel
ASTM A 36
Pressure Vessel Plates, Alloy Steel, Manganese-Vanadium
ASTM A 225
High-Strength low-Alloy Structural Steel
ASTM A 242
Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes, and Bars
ASTM A 283
Pressure Vessel Plates, Carbon Steel, low- and Intermediate-Tensile Strength
ASTM A 285
High-Strength low-Alloy Structural Manganese Vanadium Steel
ASTM A 441
Pressure Vessel Plates, Carbon Steel, Improved Transition Properties
ASTM A 442
General Requirements for Steel Sheet and Strip, Alloy, Hot-Rolled and Cold-Rolled
ASTM A 505
Steel Sheet and Strip, Alloy, Hot-Rolled and Cold-Rolled, Regular Quality
ASTM A 506
Steel Sheet and Strip, Alloy, Hot-Rolled and Cold-Rolled, Drawing Quality
ASTM A 507
High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
ASTMA 514
Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A 515
Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 516
Pressure Vessel Plates, Alloy Steel, High-Strength, Quenched and Tempered
ASTM A 517
High-Strength low-Alloy Columbium-Vanadium Steels of Structural Quality
ASTM A 572
Structural Carbon Steel Plates of Improved Toughness
ASTM A 573
Steel Bars, Carbon, Merchant Quality, M-Grades
ASTM A 575
Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM A 576
Normalized High-Strength low-Alloy Structural Steel
ASTM A 633
Steel Bars, Carbon, Merchant Quality, Mechanical Properties
ASTM A 663
Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
ASTM A 675
Miscellaneous
Pipe Hangers and Support Materials, Design and Manufacture
MSS SP-58

GENERAL NOTE:
Specific editions of standards incorporated in this Code by reference, and the names and addresses of the sponsoring organizations, are shown in Appendix A, since it is not practical to refer to a specific edition of each standard in Table 4 and throughout the Code text. Appendix A will be revised at intervals as needed and issued in Addenda to the Code.

8.0 DIMENSIONAL REQUIREMENTS

8.1 DIMENSIONAL REQUIREMENTS FOR STANDARD AND NON-STANDARD PIPING COMPONENTS

8.1.1 Standard Piping Components

Dimensional standards for piping components are listed in Table 5. Also, certain material specifications listed in Table 4 contain dimensional requirements which are requirements of section 8.1. Dimensions of piping components shall comply with these standards and specifications unless the provisions of section 8.1.2 are met.

8.1.2 Nonstandard Piping Components

The dimensions for non-standard piping components shall be such as to provide strength and performance equivalent to standard components or as provided under section 6.4. Wherever practical, these dimensions shall conform to those of comparable standard components.
8.1.3 Threads

The dimensions of all piping connection threads, not otherwise covered by a governing component standard or specification, shall conform to the requirements of the applicable standards listed in Table 5 (see section 6.12.1).

Table 5 – DIMENSIONAL STANDARDS

<table>
<thead>
<tr>
<th>Standard or Specification</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe</td>
<td></td>
</tr>
<tr>
<td>Welded and Seamless Wrought Steel Pipe</td>
<td>ANSI/ASME B 36.10M</td>
</tr>
<tr>
<td>Stainless Steel Pipe</td>
<td>ANSI/ASME B 36.19M</td>
</tr>
<tr>
<td>Line Pipe (Combination of former API Spec. 5L, 5LS, and 5EX)</td>
<td>API 5L</td>
</tr>
<tr>
<td>Ultra-High Test Heat Treated Line Pipe</td>
<td>API 5L</td>
</tr>
<tr>
<td>Fittings, Valves, and Flanges</td>
<td></td>
</tr>
<tr>
<td>Steel Pipe Flanges and Flanged Fittings</td>
<td>ANSI B 16.5</td>
</tr>
<tr>
<td>Factory-Made Wrought Steel Butt welding Fittings</td>
<td>ANSI B16.9</td>
</tr>
<tr>
<td>Face-to-Face and End-to-End Dimensions of Ferrons Valves</td>
<td>ANSI B16.10</td>
</tr>
<tr>
<td>Ring-Joint Gaskets and Grooves for Steel Pipe Flanges</td>
<td>ANSI B16.20</td>
</tr>
<tr>
<td>Nonmetallic Flat Gaskets for Pipe Flanges</td>
<td>ANSI B 16.21</td>
</tr>
<tr>
<td>Butt welding Ends</td>
<td>ANSI B 16.25</td>
</tr>
<tr>
<td>Wrought Steel Butt welding Short Radius Elbows and Returns</td>
<td>ANSI B16.28</td>
</tr>
<tr>
<td>Wellhead Equipment</td>
<td>API 6A</td>
</tr>
<tr>
<td>Pipeline Valves, End Closures, Connectors, and Swivels</td>
<td>API 6D</td>
</tr>
<tr>
<td>Steel Gate Valves, Flanged and Butt welding Ends</td>
<td>API 60</td>
</tr>
<tr>
<td>Compact Carbon Steel Gate Valves</td>
<td>API 60</td>
</tr>
<tr>
<td>Class150, Corrosion Resistant Gate Valves</td>
<td>API 60</td>
</tr>
<tr>
<td>Standard Finishes for Contact Faces of Pipe Flanges and Connecting End Flanges of Valves and Fittings</td>
<td>MSS SP-6</td>
</tr>
<tr>
<td>Standard Marking System for Valves, Fittings, Flanges and Unions</td>
<td>MSS SP-25</td>
</tr>
<tr>
<td>Steel Pipeline Flanges</td>
<td>MSSSP-44</td>
</tr>
<tr>
<td>Pressure Testing of Steel Valves</td>
<td>MSSSP-61</td>
</tr>
<tr>
<td>Butterfly Valves</td>
<td>MSSSP-67</td>
</tr>
<tr>
<td>Cast Iron Gate Valves, Flanged and Threaded Ends</td>
<td>MSS SP-70</td>
</tr>
<tr>
<td>Cast Iron Swing Check Valves, Flanged and Threaded Ends</td>
<td>MSS SP-71</td>
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<tr>
<td>Specification for High Test Wrought Welding Fittings</td>
<td>MSS SP-75</td>
</tr>
<tr>
<td>Cast Iron Plug Valves, Flanged and Threaded Ends</td>
<td>MSS SP-78</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
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<tr>
<td>Unified Screw Threads</td>
<td>ANSI B1.1</td>
</tr>
<tr>
<td>Pipe Threads</td>
<td>ANSI/ASME B1.20.1</td>
</tr>
<tr>
<td>Dry Seal Pipe Threads</td>
<td>ANSI B1.20.3</td>
</tr>
<tr>
<td>Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads</td>
<td>API 58</td>
</tr>
<tr>
<td>Pipe Hangers and Supports — Selection and Application</td>
<td>MSS SP-69</td>
</tr>
</tbody>
</table>

GENERAL NOTE:
Specific editions of standards incorporated in this Code by reference, and the names and addresses of the sponsoring organizations, are shown in Appendix A, since it is not practical to refer to a specific edition of each standard in Table 5 and throughout the Code text. Appendix A will be revised at intervals as needed, and issued in Addenda to the Code.
9.0 CONSTRUCTION, WELDING, AND ASSEMBLY

9.1 CONSTRUCTION

9.1.1 General

New construction and replacement of existing systems shall be in accordance with the requirements of this Chapter. Where written specifications are required, they shall be in sufficient detail to insure that the requirements of this Code shall be met. Such specifications shall include specific details on handling of pipe, equipment, materials, welding, and all construction factors which contribute to safety and sound engineering practice. It is not intended herein that all construction items be covered in full detail, since the specification should be all-inclusive. Whether covered specifically or not, all construction and materials shall be in accordance with good engineering, safety, and proven pipeline practice.

9.1.2 Inspection

The operation company shall make provision for suitable inspection of pipeline and related facilities by qualified inspectors to assure compliance with the construction specifications. Qualification of inspection personnel and the type and extent of inspection shall be in accordance with the requirements of section 10.1. Repairs required during new construction shall be in accordance with sections 9.1.5, 9.1.8 and 12.2.1.2.

9.1.3 Right of Way

9.1.3.1 Location

Right of way should be selected so as to minimize the possibility of hazard from future industrial or urban development or encroachment on the right of way.

9.1.3.2 Construction Requirements

Inconvenience to the landowner should be a minimum and the safety of the public shall be given prime consideration.

a) All blasting shall be in accordance with governing regulations and shall be performed by competent and qualified personnel, and performed so as to provide adequate protection to the general public, livestock, wildlife, buildings, telephone, telegraph, and power lines, underground structures, and any other property in the proximity of the blasting.

b) In grading the right of way, every effort shall be made to minimize damage to the land and prevent abnormal drainage and erosive conditions. The land is to be restored to as nearly original condition as is practical.

c) In constructing pipeline crossings of railroads, highways, streams, lakes, rivers, etc., safety precautions such as signs, lights, guard rails, etc., shall be maintained in the interest of public safety. The crossings shall comply with the applicable rules, regulations, and restrictions of regulatory bodies having jurisdiction.

9.1.3.3 Survey and Staking or Marking

The route shall be surveyed and staked, and such staking or marking should be maintained during construction, except route of pipeline offshore shall be surveyed and the pipeline shall be properly located within the right of way being maintaining survey route markers or by surveying during construction.
9.1.4 Handling, Hauling, Stringing, and storing

Care shall be exercised in the handling or storing of pipe, casing, coating materials, valves, fittings, and other materials to prevent damage. When applicable, railroad transportation of pipe shall meet the requirements of API RP 5L1. In the event pipe is yard coated or mill coated, adequate precautions shall be taken to prevent damage to the coating when hauling, lifting, and placing on the right of way. Pipe shall not be allowed to drop and strike objects which will distort, dent, flatten, gouge, or notch the pipe or damage the coating, but shall be lifted or lowered by suitable and safe equipment.

<table>
<thead>
<tr>
<th>TABLE 6 - (a) MINIMUM COVER FOR BURIED PIPELINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Industrial, commercial, and residential areas</td>
</tr>
<tr>
<td>River and stream crossings</td>
</tr>
<tr>
<td>Drainage ditches at roadways and railways</td>
</tr>
<tr>
<td>Any other area</td>
</tr>
</tbody>
</table>

GENERAL NOTE: Minimum cover for pipelines transporting LPG or liquid anhydrous ammonia shall be: 1.2m (48 in.) for normal excavation in industrial, commercial, and residential areas, river and stream crossings, and drainage ditches at roadways and railways; and 0.9m (36 in.) for normal excavation in any other area.

9.1.5 Damage to Fabricated Items and Pipe

a) Fabricated items such as scraper traps, manifolds, volume chambers, etc., shall be inspected before assembly into the mainline or manifolding and defects shall be repaired in accordance with provisions of the standard or specification applicable to their manufacturer.

b) Pipe shall be inspected before coating and before assembly into the mainline or manifolding. Distortion, buckling, denting, flattening, gouging, grooves, or notches, and all defects of this nature, shall be prevented, repaired, or eliminated as specified herein.

1) Injurious gouges, grooves, or notches shall be removed. These defects may be repaired by the use of welding procedures prescribed in API 5L or removed by grinding, provided the resulting wall thickness is not less than that permitted by the material specification.

2) When conditions outlined in section 9.1.5(b)(4) cannot be met, the damaged portion shall be removed as a cylinder. Insert patching is not permitted. Weld-on patching, other than complete encirclement, is not permitted in pipelines, intended to operate at hoop stress of more than 20% of the specified minimum yield strength of the pipe.

3) Notches or laminations on pipe ends shall not be repaired. The damaged end shall be removed as a cylinder and the pipe end properly re-bevelled.

4) Distorted or flattened lengths shall be discarded.

5) A dent (as opposed to a scratch, gouge, or groove) may be defined as a gross disturbance in the curvature of the pipe wall. A dent containing a stress concentrator, such as a scratch, gouge, groove, or arc burn, shall be removed by cutting out the damaged portion of the pipe as a cylinder.

6) All dents which affect the curvature of the pipe at the seam or at any circumferential (circumferential (girth)) weld shall be removed as in section 9.1.5(b)(5). All dents which exceed a maximum depth of 6mm (¼ in.) in pipe NPS 4 and smaller, or 6% of the nominal pipe diameter in sizes greater than NPS 4, shall not be permitted in pipelines intended to operate at a hoop stress of more than 20% of the specified minimum yield strength of the pipe. Insert patching, overlay, or pounding out of dents shall not be permitted in pipelines intended to operate
at a hoop stress of more than 20% of the specified minimum yield strength of the pipe.

7) Buckled pipe shall be replaced as a cylinder.

9.1.6 Ditching

a) Depth of ditch shall be appropriate for the route location, surface use of the land, terrain features, and loads imposed by roadways and railroads. All buried pipelines shall be installed below the normal level of cultivation and with a minimum cover not less than that shown in Table 6. Where the cover provisions of Table 6 cannot be met, pipe may be installed with less cover if additional protection is provided to withstand anticipated external loads and to minimize damage to the pipe by external forces.

b) Width and gradient of ditch shall provide for lowering of the pipe into the ditch to minimize damage to the coating and to facilitate fitting the pipe to the ditch.

c) Location of underground structures intersecting the ditch route shall be determined in advance of construction activities to prevent damage to such structures. A minimum clearance of 0.3m (12 in.) shall be provided between the outside of any buried pipe or component and the extremity of any other underground structures, except for drainage tile which shall have a minimum clearance of 50mm (2 in.), and as permitted under section 12.2.1.1.(d).

d) Ditching operations shall follow good pipeline practice and consideration of public safety. API RP 1102 will provide additional guidance.

9.1.7 Bends, Mitres, and Elbows

Changes in direction, including sags or overbends required to conform to the contour of the ditch, may be made by bending the pipe or using mitered, factory made bends, or elbows. [See limitations in section 6.6.2].

9.1.7.1 Bends Made From Pipes

a) Bends shall be made from pipe having wall thicknesses determined in accordance with section 6.2.2.1. When hot bends are made in pipe which has been cold worked in order to meet the specified minimum yield strength, wall thicknesses shall be determined by using the lower stress values in accordance with 6.2.3.1. (d).

b) Bends shall be made in such a manner as to preserve the cross-sectional shape of the pipe, and shall be free from buckling, cracks, or other evidence of mechanical damage. The pipe diameter shall not be reduced at any point by more than 2½% of the nominal diameter, and the completed bend shall pass the specified sizing pig.

c) The minimum radius of field cold bends shall be as specified in 6.6.2.1(b).

d) Tangents approximately 2m (6ft) in length are preferred on both ends of cold bends.

9.1.7.2 Mitered Bends

a) Mitered bends are permitted subject to limitation in section 6.6.2.2.

b) Care shall be taken in making mitered joints to provide proper spacing and alignment and full penetration welds.

9.1.7.3 Factory Made Bends and Elbows

a) Factory made wrought steel welding bends and factory made elbows may be used subject to limitations in section 6.6.2.3, and transverse segments cut there from may be used for changes in direction provided the arc distance measured along the crotch is at least 2 in. (50mm) on pipe size NPS 4 and larger.

b) If the internal diameter of such fittings differs by more than 5mm (3/16 in.) from that of the pipe, the fitting shall
be treated as indicated in Fig. 9 or use a transition nipple not less than one-half pipe diameter in length with acceptable joint designs as illustrated in Fig. 9.

9.1.8 Welding

9.1.8.1 General

a) Scope. Welding herein applies to the arc and gas welding of pipe in both wrought and cast steel materials as applied in pipelines and connections to apparatus or equipment. This includes butt joints in the installation of pipe, valves, flanges, fittings, and other equipment, and fillet welded joints in pipe branches, slip-on flanges etc. It does not apply to the welding of longitudinal or spiral joints in the manufacture of pipe, fittings, and valves, or to pressure vessels or assemblies manufactured in accordance with the ASME Boiler and pressure Vessel Code, Section VIII, Division 1 and 2.

b) Welding Terms. Definitions pertaining to welding as used in this Code conform to the standard definitions established by the American Welding Society and contained in ANSI/AWS A3.0 and API 1104.

c) Safe Practices in Cutting and Welding. Prior to cutting and welding in areas in which the possible leakage or presence of vapour or flammable liquid constitutes a hazard of fire or explosion, a thorough check shall be made to determine the presence of a combustible gas mixture or flammable liquid. Cutting and welding shall begin only when safe conditions are indicated.

9.1.8.2 Welding Processes and Filler Metal.

Welding shall be done by shielded metal arc welding, submerged arc welding, gas tungsten arc welding, gas metal arc welding, or oxyacetylene welding process using a manual, semiautomatic, or automatic welding technique or combination of these techniques. Filler metal shall comply with the requirements of API 1104.

9.1.8.3 Welding Qualifications

a) Prior to any welding covered by this Code, a welding procedure shall be established and qualified by testing to demonstrate that welds having suitable mechanical properties and soundness can be continuously produced. Welding procedures and each welder or welding operator shall be qualified under API 1104, or Section IX of the ASME Boiler and Pressure Vessel Code, whichever is appropriate for the type of welding to be performed. The qualified welding procedure shall specify the preheating and interpass temperature, and postweld heat treatment followed when materials, welding consumables, mechanical restraints, or weather conditions make any or all of them necessary. The welding procedure shall be adhered to during welding performed under this Code.

b) API 1104 and Section IX of the ASME Boiler and Pressure Vessel Code contained sections entitled “Essential Variables” applicable to welding procedures and also to welders. These shall be followed except that for the purposes of this Code, all carbon steels which have a carbon content not exceeding 0.32% (heat analysis) and a carbon equivalent (C + 1/6 Mn) not exceeding 0.65% (heat analysis) are considered to come within the limits of materials listed as P1, in Section VIII, Division 1 or 2, or Section IX. Alloy steels having weldability characteristics demonstrated to be similar to these carbon steels shall be welded, preheated, and postweld heat treated as prescribed for such carbon steels. Other alloy steels shall be welded, preheated, and given a postweld heat treatment as prescribed in Section VIII, Division 1 or 2, unless it can be demonstrated by procedure qualification, and hardness testing per NACE MR-01-75 when applicable, that preheat or postweld heat treatment, or both, are not necessary.

c) Welder requalification tests shall be required if there is some specific reason to question a welder’s ability or the welder is not engaged in a given process of welding (i.e., arc or gas) for a period of 6 months or more.

d) Qualification Records. The welding procedure followed during the qualifying tests shall be recorded in detail. Records of the tests that establish the qualification of a welding procedure shall be retained as long as that procedure is in use. A record of the welders qualified, showing the date and results of the tests, shall be retained during the construction involved and for 6 months thereafter.
e) The operating company shall be responsible for qualifications of procedures and welders.

**9.1.8.4 Welding Standards**

All the welding done under this Code shall be performed under a specification which embodies the minimum requirements of this Code and shall encompass the requirements of API 1104 except as provided in sections 9.1.8.3(1) and (b).

**9.1.8.5 Welding Quality**

a) **Inspection Methods**

1) The quality of welding shall be checked by nondestructive methods or by removing completed welds as selected and designated by the inspector for destructive testing.

2) Nondestructive inspection shall consist of radiographic examination or other acceptable nondestructive methods. The method used shall produce indications of potential defects which can be accurately interpreted and evaluated. Radiographic examination, when employed, shall meet the requirements under "Radiographic Procedure" in API 1104. The welds shall be evaluated on the basis of section 9.1.8.5(b).

3) To be acceptable, completed welds which have been removed for destructive examination shall meet the requirements of API 1104 for Welder Qualification by Destructive Testing. Trepanning methods of testing shall not be used.

4) When the pipeline is to be operated at a hoop stress of more than 20% of the specified minimum yield strength of the pipe, certain circumferential (circumferential (girth)) welds shall be inspected. A minimum of 10% of the welds completed each day shall be randomly selected by the operating company and inspected. The inspection shall be by radiographic or other acceptable nondestructive methods (visual inspection excepted). Each weld inspected shall be inspected completely around its circumference. In the following locations or conditions, all circumferential (girth) welds in the pipe shall be completely inspected. If some of the circumferential (girth) welds are inaccessible, a minimum of 90% of the welds are to be inspected.

   (a) Within populated areas such as residential subdivisions, shopping centres, and designated commercial and industrial areas;

   (b) River, lake, and stream crossings within the area subject to frequent inundation; and river, lake, and stream crossings;

   (c) Railroad or public highway rights of way include tunnels, bridges, and overhead railroad and road crossings;

   (d) Offshore and inland coastal waters;

   (e) Old circumferential (girth) welds in used pipe;

   (f) Tie-in circumferential (girth) welds not hydrostatically tested in accordance with section 10.2.2.1

b) **Standards of Acceptability.** Standards of acceptability for inadequate penetration and incomplete fusion, burnthrough, slag inclusions, porosity or gas pockets, cracks, accumulation of discontinuities, and undercutting as set forth under “Standards of Acceptability – Nondestructive Testing” in API 1104 are applicable to the determination of the size and type of discontinuities located by visual inspection, radiography, or other nondestructive methods. These standards shall not be used to determine the quality of welds which are subjected to destructive testing.

**9.1.8.6 Types of Welds, Joint Designs, and Transition Nipples**
a) **Butt Welds.** Butt welded joints may be of the single vee, double vee, or other suitable type of groove. Joint designs shown in Fig. 8 or applicable combination of these joint designs are recommended for ends of equal thickness. The transition between ends of unequal thickness may be accomplished by taper or welding as shown in Fig. 9, or by means of a prefabricated transition nipple not less than one-half pipe diameter in length with acceptable joint designs as illustrated in Fig. 9.

![Acceptable Combinations of Pipe End Preparations](image)

**Figure 8. Acceptable Butt Welded joint Design for Equal Wall Thicknesses**
NOTES:
(1) No minimum when materials joined have equal yield strength [see general Note (f)].
(2) Maximum thickness $t_0$ for design purposes shall not be greater than 1.5.

GENERAL NOTES:
(a) The sketches in Fig. 9 illustrate acceptable preparations for joining pipe ends having unequal wall thickness or/and materials of unequal specified minimum yield strength by butt welding.
(b) The wall thickness of the pipes to be joined, beyond the joint design area, shall comply with the design requirements of this Code.
(c) When the specified minimum yield strengths of the pipes to be joined are unequal, the deposited weld metal shall have mechanical properties at least equal to those of the pipe having the higher strength.
(d) The transition between ends of unequal thickness may be accomplished by taper or welding as illustrated or by means of a prefabricated transition nipple not less than one-half pipe diameter in length.
(e) Sharp notches or grooves at the edge of the weld where it joins a slanted surface shall be avoided.
(f) For joining pipes of unequal wall thicknesses and equal specified minimum yield strengths, the rules given herein apply, except there is no minimum angle limit to the taper.
(g) The effective weld throat shall be used for determining postweld heat treatment requirements.

INTERNAL DIAMETERS UNEQUAL
(1) If the nominal wall thicknesses of the adjoining pipe ends do not vary more than 3/32 in (2.5 mm), no special treatment is necessary provided full penetration and bond is accomplished in welding. See sketch (a).
(2) Where the nominal internal offset is more than 2.5 mm (3/32 in.) and there is no access to the inside of the pipe for welding, the transition shall be made by a taper cut on the inside end of the thicker pipe. See sketch (b). The taper angle shall not be steeper than 30 deg. not less than 14 deg.
(3) For hoop stresses of more than 20% of the specified minimum yield strength of the pipe, where the nominal internal offset is more than 2.5 mm (3/32 in.), but does not exceed one-half the wall thickness of the thinner pipe, and there is access to the inside of the pipe for welding, the transition may be made with a tapered weld. See sketch (c).
The land on the thicker pipe shall be equal to the offset plus the land on abutting pipe.

(4) Where the nominal internal offset is more than one-half the wall thickness of the thinner pipe, and there is access to the inside of the pipe for welding, the transition may be made with a taper cut on the inside end of the thicker pipe [see sketch (b)], or by a combination taper weld to one-half the wall thickness of the thinner pipe and a taper cut from the point [see sketch (d)]

EXTERNAL DIAMETERS UNEQUAL

(5) Where the external offset does not exceed one-half the wall thickness of the thinner pipe, the transition may be made by welding [see sketch (e)], provided the angle of rise of the weld surface does not exceed 30 deg., and both bevel edges are properly fused.

(6) Where there is an external offset exceeding one-half the wall thickness of the thinner pipe, the transition may be made by Wall thickness of the thinner pipe shall be tapered. See sketch (f).

INTERNAL AND EXTERNAL DIAMETERS UNEQUAL

(7) Where there is both an internal and an external offset, the joint design shall be a combination of sketches (a) to (f), see Sketch (g). Particular attention shall be paid to proper alignment under these conditions.

**Figure 9. Acceptable butt welded joint design for unequal wall thicknesses**

b) *Fillet Welds.* Fillet welds may be concave to slightly convex. The size of a fillet weld is stated as a leg length of the largest inscribed right isosceles triangle as shown in Fig. 10 covering recommended attachment details of flanges.

c) *Tack Welds.* Tack welding shall be done by qualified welders, the same as all other welds.

9.1.8.7 Removal or Repair of Defects

a) *Arc Burns.* Arc Burns can cause serious stress concentrations in pipelines and should be prevented or eliminated. The metallurgical notch caused by arc burns shall be removed by grinding, provided the grinding does not reduce the remaining wall thickness to less than the minimum permitted by the material specifications. Complete removal of the metallurgical notch created by an arc burn can be determined as follows. After visible evidence of the arc burn has been removed by grinding, swab the ground area with a 20% solution of ammonium persulphate. A blackened spot is evidence of a metallurgical notch and indicates that additional grinding is necessary. If the resulting wall thickness after grinding is less than that permitted by the material specification, the portion of pipe containing the arc burn shall be removed as a cylinder. Insert patching is prohibited.

b) *Weld Defect.* Authorisation for repair of welds, removal and repair of weld defects and testing of weld repairs shall be in accordance with API 1104.

c) *Pipe Defects.* Laminations, split ends or other defects in the pipe shall be repaired or removed in accordance with section 9.1.5(b).

9.1.8.8 Preheating and Interpass Temperature

a) Carbon steels having a specified carbon content in excess of 0.32% (heat analysis) or a carbon equivalent (C + ¼ Mn) in excess of 0.65% (heat analysis) shall be preheated. Preheating may also be required for steels having lower carbon or carbon equivalent when conditions exist that either limit the welding technique that can be used, or tend to adversely affect the quality of the weld. Interpass temperature control may also be required.

b) When welding dissimilar materials having different preheating requirements, the material requiring the higher preheat shall govern.
c) Preheating may be accomplished by any suitable method, provided that it is uniform and that the temperature does not fall below the prescribed minimum during the actual welding operations.

d) The preheating temperature shall be checked by the use of temperature indicating crayons, thermocouple pyrometers, or other suitable method to assure that the required temperature is obtained prior to and maintained during the welding operation.

Figure 10. Recommended attachment details of flanges

9.1.8.9 Stress Relieving

a) Welds shall be stress relieved when the effective weld throat [see Fig. 9] exceeds 1¼ in. (32 mm), unless it can be demonstrated by welding procedure qualification tests, using materials with an effective weld throat that is equal to or greater than the production weld, that stress relieving is not necessary.
Welds in carbon steels with effective weld throat above 32 mm (1¼ in.) up to and including 38 mm (1½ in.) may be exempted from stress relieving if a minimum preheating temperature of 100ºC (212ºF) is used. Stress relieving may be required for thinner effective weld throats when materials, welding consumables, weld process, transported liquids, or temperature make it necessary.

The thickness to be used to determine the stress relieving requirements of branch connections or slip-on flanges shall be the thickness of the pipe or header.

b) In welds between dissimilar materials, if either material requires stress relieving, the joint shall require stress relieving.

9.1.9 Tie-In

Gaps left in the continuous line construction at such points as river, canal, highway, or railroad crossings require special consideration for alignment and welding. Sufficient equipment shall be available and care exercised not to force or strain the pipe to proper alignment.

9.1.10 Installation of Pipe in the Ditch

It is very important that stresses induced into the pipeline by construction be minimized. The pipe shall fit the ditch without the use of external force to hold it in place until the backfill is completed. When the pipe is lowered into the ditch, care shall be exercised so as not to impose undue stress in the pipe. Slack loops may be used where laying conditions render their use advisable.

9.1.11 Backfilling

Backfilling shall be performed in a manner to provide firm support to the pipe. When there are large rocks in the backfill material, care shall be exercised to prevent damage to the pipe and coating by such means as the use of a road shield material, or by making the initial fill with a rock-free material sufficient to prevent rock damage. Where the ditch is flooded, care shall be exercised so that the pipe is not floated from the bottom of the ditch prior to backfill completion.

9.1.12 Restoration of Right of Way and Cleanup

These operations shall follow good construction practices and consideration of private and public safety.

9.1.13 Special Crossings

Water, railroad, and highway crossings require specific considerations not readily covered in a general statement, since all involve variations in basic design. The pipeline company shall obtain required permits for such crossings. The design shall employ sound engineering and good pipeline practice with minimum hazard to the facility and due consideration of public safety. Construction shall be so organized as to result in minimal interference with traffic or the activities of adjacent property owners. Adequate efforts shall be made to determine the location of buried pipelines, utility lines, and other underground structures along and crossing the proposed right way. The owners of any affected structures shall be given adequate prior notice of the proposed construction so that the owner may make operational presectiontions and provide a representation at the crossing.

9.1.13.1 Water Crossings

Crossings of rivers, streams, lakes and inland bodies of water are individual problems, and the designer shall investigate composition of bottom, variation in banks, velocity of water, scouring, and special seasonal problems. The designer shall determine whether the crossing is to be underwater, overhead on a suspension bridge, or supported on an adjacent bridge. Continuity of operation and the safety of the general public shall be the controlling factors both in design and in construction. Where required, detailed plans and specifications shall be prepared taking into account these and any special considerations or limitations imposed by the regulatory body involved.
a) **Underwater Construction.** Plans and specifications shall describe the position of the line showing relationship of the pipeline to the natural bottom and the depth below mean low water level when applicable. To meet the conditions set out in section 9.1.13.1, heavier wall pipe may be specified. Approach and position of the line in the banks is important, as is the position of the line across the bottom. Special consideration shall be given to depth of cover and other means of protecting the pipeline in the surf zone. Special consideration shall be give to protective coating and the use of concrete jacketing or the application of river weights. Complete inspection shall be provided. Precautions shall be taken during construction to limit stress below the level that would produce buckling or collapse due to out-of-roundness of the completed pipeline.

9.1.13.2 Overhead Structures

Overhead structures used to suspend pipelines shall be designed and constructed on the basis of sound engineering and within the restrictions or regulations of the governing body having jurisdiction. Detailed plans and specifications shall be prepared where required and adequate inspection shall be provided to assure complete adherence thereto.

9.1.13.3 Bridge Attachment

Special requirements are involved in this type of crossing. The use of higher strength lightweight steel pipe, proper design and installation of hangers, and special protection to prevent damage by the elements or bridge and approach traffic shall be considered. Any agreed upon restrictions or precautions shall be contained in the detailed specifications. Inspectors shall assure themselves that these requirements are met.

9.1.13.4 Rail and Road Crossings

a) The safety of the general public and the prevention and damage to the pipeline by reason of its location are primary considerations. The great variety of such crossings precludes standard design. The construction specifications shall cover the procedure for such crossings, based upon the requirements of the specific locations.

b) Installation of uncased carrier pipe is preferred. Installation of carrier pipe, or casing if used, shall be in accordance with API RP1102. As specified in section 12.2.1.2(d), if casing is used, coated carrier pipe shall be independently supported outside each end of the casing and insulated from the casing throughout the cased section, and casing ends shall be sealed using a durable electrically nonconductive material.

c) The sum of the circumferential stresses due to internal design pressure and external load in pipe installed under rail or roads without use of casing shall not exceed the allowable circumferential stresses noted in section 6.2.3.2(e).

9.1.14 Offshore and Inland Coastal Water Construction

Plans and specifications shall describe alignment of the pipeline, depth below mean water level, and depth below bottom if ditched. Special consideration shall be given to depth of cover and other means of protecting the pipeline in the surf zone. Consideration shall be given to use of weight coating(s), anchors, or other means of maintaining position of the pipe under anticipated conditions of buoyancy and water motion. Complete construction inspection shall be provided. Precautions shall be taken during construction to limit stress below the level that would produce buckling or collapse due to out-of-roundness of the completed pipeline. API RP 1111 may be used as a guide.

9.1.15 Block and Isolating Valves

9.1.15.1 General

a) Block and isolating valves shall be installed for limiting hazard and damage from accidental discharge for facilitating maintenance of the piping system.

b) Valves shall be at accessible locations, protected from damage or tampering, and suitably supported to prevent differential settlement or movement of the attached piping. Where an operating device to open or close the valve is provided, it shall be protected and accessible only to authorized persons.
c) Pipeline valves on offshore platforms shall be located for easy access to permit isolation of the piping system.

d) Submerged valves on pipelines shall be marked or spotted by survey techniques to facilitate quick location when operation is required.

9.1.15.2 Mainline Valves

a) Mainline block valves shall be installed on the upstream side of major river crossings and public water supply reservoirs. Either a block or check valve shall be installed on the downstream side of major river crossings and public water supply reservoirs.

b) A mainline block valve shall be installed at mainline pump stations, and a block or check valve (where applicable to minimise pipeline backflow) shall be installed at other locations appropriate for the terrain features. In industrial, commercial, and residential areas where construction activities pose a particular risk of external damage to the pipeline, provisions shall be made for the appropriate spacing and location of mainline valves consistent with the type of liquids being transported.

c) A remotely operated mainline block valve shall be provided at remotely controlled pipeline facilities to isolate segments of the pipeline.

d) On piping systems transporting LPG, check valves shall be installed where applicable with each block valve to provide automatic blockage of reverse flow in the piping system.

e) In order to facilitate operational control, limit the duration of an outage, and to expedite repairs, mainline block valves shall be installed at 12 km (7.5 mile) maximum spacing on piping systems transporting LPG in industrial, commercial, and residential areas.

9.1.15.3 Pump Station, Tank Farm, and Terminal Valves

a) Valves shall be installed on the suction and discharge of pump stations whereby the pump station can be isolated from the pipeline.

b) Valves shall be installed on lines entering or leaving tank farms or terminals at convenient locations whereby the tank farm or terminal may be isolated from the facilities such as the pipeline, manifolds, or pump stations.

9.1.16 Connections to Main Lines

Where connections to the main line such as branch lines, jump-over, relief valves, air vents, etc., are made to the main line, they shall be made in accordance with section 6.4.3.1. When such connections or additions are made to coated lines, all damaged coating shall be removed and replaced with new coating material in accordance with section 12.2.1.2(h). This protective coating should include the attachments.

9.1.17 Scraper (Pigging) Traps

9.1.17.1 Scraper traps are to be installed as deemed necessary for good operations. All pipe, valves, fittings, closures, and appurtenances shall comply with appropriate sections of this Code.

9.1.17.2 Scraper traps on mainline terminations and tied into connection piping or manifolding shall be anchored below ground with adequate concrete anchors when required and suitably supported above ground to prevent transmission of line stresses due to expansion and contraction to connecting facilities.

9.1.17.3 Scraper trap and its components shall be assembled in accordance with section 9.2, and pressure tested to the same limits as the mainline. See section 10.2.2

9.1.18 Line Markers
Adequate pipeline location markers indicating caution for the protection of the pipeline, the public, and persons performing work in the area shall be installed over each line on each side of road, highway, railroad, and stream crossings. Markers are not required for pipelines offshore. Markers in accordance with requirements of regulatory agencies shall be installed on each side of navigable stream crossings. API RP 1109 shall be used for guidance.

9.1.19 Corrosion Control

Protection of ferrous pipe and components from external and internal corrosion shall be as prescribed in Clause 12.0.

9.1.20 Pump Station, Tank Farm, and Terminal Construction

9.1.20.1 General

All construction work performed on pump stations, tank farms, terminals, equipment installations, piping, and allied facilities shall be done under construction specifications. Such specifications shall cover all phases of the work under contract and shall be in sufficient detail to ensure that the requirements of this Code shall be met. Such specifications shall include specific details on soil conditions, foundations and concrete work, steel fabrication and building erection, piping, welding, equipment and materials, and all construction factors contributing to safety and sound engineering practice.

9.1.20.2 Location

Pump stations, tank farms, and terminals should be located on the pipeline’s fee or leased property in order to be assured that proper safety precautions may be applied. The pump station, tank farm, or terminal shall be located at such clear distances from adjacent properties not under control of the company as to minimise the communication of fire from structures on adjacent properties. Similar consideration shall be given to its relative locations from the station manifolds, tankage, maintenance facilities, personnel housing, etc. Sufficient open space shall be left around the building and manifolds to provide access for maintenance equipment and fire fighting equipment. The station, tank farm, or terminal shall be fenced in such a manner as to minimize trespass, and roadways and gates should be located to give ready access to or egress from the facilities.

9.1.20.3 Building Installation

Buildings shall be located and constructed to comply with detailed plans and specifications. The excavation for and installation of foundations and erection of the building shall be done by craftsmen familiar with the respective phase of the work, and all work shall be done in a safe and workmanlike manner. Inspection shall be provided to assure that the requirements of the plans and specifications are met.

9.1.20.4 Pumping Equipment and Prime Movers

Installation of pumping equipment and prime movers shall be covered by detailed plans and specifications which have taken into account the variables inherent in local soil conditions, utilisation, and arrangement of the equipment to provide the optimum in operating ease and maintenance access. Machinery shall be handled and mounted in accordance with recognised good millwright practice and be provided with such protective covers as to prevent damage during construction. Recommendation of installation details provided by manufacturers for auxiliary piping, setting, and aligning shall be considered as minimum requirements.

9.1.20.5 Pump Station, Tank Farm, and Terminal Piping

All piping, including but not limited to main unit interconnections, manifolds, scraper traps, etc., which can be subject to the mainline pressure shall be constructed in accordance with the welding standards (see section 9.1.8), corrosion control requirements (see clause 12.0), and other practices of this Code.

9.1.20.6 Controls and Protective Equipment
Pressure controls and protective equipment, including pressure limiting devices, regulators, controllers, relief valves,
and other safety devices, as shown on the drawings or required by the specifications, shall be installed by competent
and skilled personnel. Installation shall be accomplished with careful handling and minimum exposure of instruments
and devices to inclement weather conditions, dust, or dirt to prevent damage. In addition, piping, conduits, or
mounting brackets shall not cause the instruments or devices to be distorted or shall not be subjected to any strain.
Instruments and devices shall be installed so that they can be checked without undue interruptions in operations.
After installation, controls and protective equipment shall be tested under conditions approximating actual
operations to assure their proper function.

9.1.20.7 Fire Protection

Fire protection when provided shall be in accordance with recommendation in ANSI/NFPA 30 and ZS 385 Part 1. If
the system installed requires the services of fire pumps, their motive power shall be separated from the station power
so that their operation shall not be affected by emergency shutdown facilities.

9.1.21 Storage and Working Tankage

9.1.21.1 General

All construction work performed on storage and working tankage and allied equipment, piping, and facilities shall be
done under construction specifications. Such specifications shall cover all phases of the work under contract, and
shall be in sufficient detail to ensure that the requirements of the Code shall be met. Such specifications shall include
specific details on soil conditions, foundations and concrete work, tank fabrication and erection, piping, welding,
equipment and materials, dikes, and all construction factors contributing to safety and sound engineering practice.

9.1.21.2 Location

a) Tankage shall be located on the pipeline’s fee or leased property in order to assure that proper safety
precautions may be applied. Tank facilities shall be located at such clear distances from adjacent properties not
under control of the company as to minimise the communication of fire from structures on adjacent properties. Similar
consideration shall be given to relative location between station manifolds, pumping equipment, maintenance
facilities, personnel housing, etc. Sufficient open space shall be left around the tankage facilities and associated
equipment to provide access for maintenance and fire fighting equipment. The tankage area shall be fenced so as to
minimise trespass, and roadways and gates should be located to give ready ingress to and egress from the facilities.
b) Spacing of tankage shall be governed by the requirements of ANSI/NFPA 30 /ZS 385 Part 1.

9.1.21.3 Tanks and Pipe-Type Storage

a) Tanks for storage or handling crude oil and liquid petroleum products and liquid alcohols having vapour
pressures approximating atmospheric shall be constructed in accordance with ANSI/API 650, API 12B, API 12D, API
12F, ZS 385-1, or designed and constructed in accordance with accepted good engineering practices.
b) Tanks for storage or handling liquid petroleum products and liquid alcohols having vapour gauge pressures of
0.025 bar (0.5 psi) but not exceeding 1 bar (15 psi) shall be constructed in accordance with ANSI/API 620.
c) Tanks used for storage or handling liquids having vapour gauge pressures greater than 1 bar (15 psi) shall be
designed and constructed in accordance with the design of accredited tank builders and the ASME Boiler and
Pressure Vessel Code, Section VIII, Division 1 or Division 2.
d) Buried pipe-type holders used for storage and handling liquid petroleum, liquid alcohols, shall be designed and
constructed in accordance with the requirements of this Code for pipe and piping components.

9.1.21.4 Foundations

Tank foundations shall be constructed in accordance with plans and specifications which shall take into account
local soil conditions, type of tank, usage, and general location.

9.1.21.5 Dykes or Firewalls

The protection of the pipeline’s station, tank farm, terminal, or other facilities from damage by fire from adjacent facilities, as well as the protection of the general public, may dictate the need of dikes or firewalls around tankage or between tankage and station or terminal. Tank dikes or firewalls, where required, shall be constructed to meet the capacity requirements set out in ANSI/NFPA 30/ZS 385-1.

9.1.22 Electrical Installations

9.1.22.1 General

Electrical installations for lighting, power, and control shall be covered by detailed plans and specifications, and installations shall be in accordance with codes applicable to the specific type of circuitry and classification of areas for electrical installation. Inspection shall be provided and all circuitry shall be tested before operation to assure that the installation was made in workmanlike manner to provide for the continuing safety of personnel and equipment. Installations shall be made in accordance with ANSI/NFPA 70 and API RP 500C ZS 402, ZS 385-2.

9.1.22.2 Care and Handling of Materials

All electrical equipment and instruments shall be carefully handled and properly stored or enclosed to prevent damage, deterioration, or contamination during construction. Packaged components are not to be exposed until installation. Equipment susceptible to damage or deterioration by exposure to humidity shall be adequately protected by using appropriate means such as plastic film enclosures, desiccants, or electric heating.

9.1.22.3 Installation

The installation of electrical materials shall be made by qualified personnel familiar with details of electrical aspects and code requirements for such installation. At all times care shall be exercised to prevent damage to the insulation of cable and wiring. All partial installations shall be protected from damage during construction. The installation design and specifications shall give consideration to the need for dust- and/or moisture-proof enclosures for such special gear as relays, small switches, and electronic components. In no case shall the frames of electric motors or other grounded electrical equipment be used as the ground connection for electrical welding.

9.1.23 Liquid Metering

9.1.23.1 Positive displacement meters, turbine meters, or equivalent liquid measuring devices and their proving facilities shall be designed and installed in accordance with the API Manual of Petroleum Measurement Standard.

9.1.23.2 Provision shall be made to permit access to these facilities by authorized personnel only.

9.1.23.3 Assembly of the metering facility components shall be in accordance with section 9.2.

9.1.24 Liquid Strainers and Filters

9.1.24.1 Strainers and filters shall be designed to the same pressure limitations and subjected to the same test pressures as the piping system in which they are installed, and supported in such a manner as to prevent undue loading to the connecting piping system.

9.1.24.2 Installation and design shall provide for ease of maintenance and servicing without interference with the station operation.

9.1.24.3 The filtering medium should be of such retention size and capacity as to fully protect the facilities against the intrusion of harmful foreign substances.
9.1.24.4 Assembly of strainers or filters and their components shall be in accordance with section 9.2.

9.2 ASSEMBLY OF PIPING COMPONENTS

9.2.1 General

The assembly of the various piping components, whether done in a shop or as a field erection, shall be done so that the completely erected piping conforms with the requirements of this Code and with the specific requirements of the engineering design.

9.2.2 Bolting Procedure

9.2.2.1 All flanged joints shall be fitted up so that the gasket contact faces bear uniformly on the gasket, and made up with uniform bolt stress.

9.2.2.2 In bolting gasketed flanged joints, the gasket shall be properly compressed in accordance with the design principles applicable to the type of gasket used.

9.2.2.3 All bolts or studs shall extend completely through their nuts.

9.2.3 Pumping Unit Piping

9.2.3.1 Piping to main pumping units shall be so designed and supported that when assembled to the pump flanges and valves it should be relatively free of stress and should not add stress or load to the pump frame.

9.2.3.2 The design and assembly shall take into account the forces of expansion and contraction to minimize their effect within the assembly.

9.2.3.3 All valves and fittings on pumping units shall carry the same pressure ratings as required for line operating pressures.

9.2.3.4 Welding shall be in accordance with section 9.1.8 of the Code.

9.2.3.5 Bolting shall be in accordance with section 9.2.2.

9.2.4 Manifolds

9.2.4.1 All components within a manifold assembly, including valves, flanges, fittings, headers, and special assemblies, shall withstand the operating pressures and specified loadings for the specific service piping to which it is connected.

9.2.4.2 Meter banks, prover loops, and scraper traps shall be subject to the same assembly requirements as manifolds.

9.2.4.3 Manifolds headers with multiple outlets shall have outlets designed as covered in section 6.4.3.1(b) and 6.4.3.1(e) and illustrated in figs. 2 and fig. 6, respectively. Assembly may be with use of jigs to assure alignment of outlets and flanges with other components. The fabricated unit shall be stress relieved before removal from the jig.

9.2.4.4 Manifold headers assembled from wrought tees, fittings, and flanges may be assembled with jigs to assure alignment of components. Stress relieving should be considered.

9.2.4.5 All welding on manifolds and headers shall conform to section 9.1.8.

9.2.4.6 Final assembly of all components shall minimize locked-in-stresses. The entire assembly shall be adequately supported to provide minimum unbalance and vibration.
9.2.5 Auxiliary Liquid hydrocarbon piping

9.2.5.1 All auxiliary piping between main units and auxiliary components shall be assembled in a professional manner and in accordance with the applicable code.

9.2.5.2 All welded auxiliary lines shall be assembled in accordance with the requirements of this Code with special provisions as required for assembly to minimize locked-in-stress, and for adequate support or restraint to minimize vibration.

10.0 INSPECTION AND TESTING

10.1 INSPECTION

10.1.1 General

Construction inspection provisions for pipelines and related facilities shall be adequate to assure compliance with the material, construction, welding, assembly and testing requirements of this Code.

10.1.2 Qualification of Inspectors

Inspection personnel shall be qualified by training and experience, such personnel shall be capable of performing the following inspection services:

a) right of way and grading;
b) ditching;
c) line up and pipe surface inspection;
d) welding;
e) coating;
f) tie-in and lowering;
g) backfilling and clean up;
h) pressure testing;
i) special services for testing and inspection of facilities such as station construction, river crossings, electrical installation, radiography, corrosion control, etc., as may be required.

10.1.3 Type and Extent of Examination Required

10.1.3.1 Visual

a) Material

1) All piping components shall be visually inspected to insure that no mechanical damage has occurred during shipment and handling prior to being connected into the piping system.

2) All pipe shall be visually inspected to discover any defects as described in section 9.1.5 and 9.1.8.7.

3) On systems where pipe is telescoped by grade, wall thickness, or both, particular care shall be taken to ensure proper placement of pipe. Permanent records shall be kept showing the location as installed of each grade, wall thickness, type, specification, and manufacturer of the pipe.

b) Construction

1) Visual inspection for detection of surface defects in the pipe shall be provided for each job just ahead of any coating operation and during the lowering-in and backfill operation.
2) The pipe swabbing operation shall be inspected for thoroughness to provide a clean surface inside the pipe.

3) Before welding, the pipe shall be examined for damage-free bevels and proper alignment of the joint.

4) The stringer bead shall be inspected, particularly for cracks, before subsequent beads are applied.

5) The completed weld shall be cleaned and inspected prior to coating operations, and irregularities that could protrude through the pipe coating shall be removed.

6) When the pipe is coated, inspection shall be made to determine that the coating machine does not cause harmful gouges or grooves in the pipe surface.

7) Lacerations of the pipe coating shall be inspected prior to repair of coating to see if the pipe shall be repaired before the pipe is lowered in the ditch.

8) All repairs, changes, or replacements shall be inspected before they are covered up.

9) The condition of the ditch shall be inspected before the pipe is lowered in to assure proper protection of pipe and coating. For underwater crossings and offshore pipelines, the condition of the ditch and fit of the pipe in the ditch shall be inspected when feasible.

10) The fit of the pipe to ditch shall be inspected before the backfilling operations.

11) Except for offshore pipelines, the backfilling operations shall be inspected for quality and compaction of backfill, placement of material for the control of erosion, and possible damage to the pipe coatings. For offshore pipelines the backfill shall be inspected when feasible.

12) Cased crossings shall be inspected during installation to determine that the carrier pipe is supported, sealed, and insulated from the casing.

13) River crossings shall have thorough inspection, and shall be surveyed and profiled after construction.

14) All piping components other than pipe shall be inspected to ensure damage-free condition and proper installation.

10.1.3.2 Supplementary Types of Examination

Testing of field and shop welds shall be made in accordance with section 9.1.8.5.

Radiographic inspection of welds shall be performed in accordance with section 9.1.8.5.

Coated pipe shall be inspected in accordance with section 12.2.1.2.

10.1.4 Repair of Defects

10.1.4.1 Defects of fabricated items and in pipe wall shall be repaired or eliminated in accordance with section 9.1.5.

10.1.4.2 Welding defects shall be repaired in accordance with section 9.1.8.7.

10.1.4.3 Holidays or other damages to coatings shall be repaired in accordance with section 12.2.1.2.

10.2 TESTING

10.2.1 General

a) In order to meet requirements of this Code, it is necessary that tests be made upon the completed system and
upon component parts of the finished system. When reference in this Code is made to tests or portions of tests described in other codes and specifications, they shall be considered as a part of this Code.

b) Should leaks occur on tests, the line section or component part shall be repaired or replaced and retested in accordance with this Code.

10.2.1.1 Testing of Fabricated Items

a) Fabricated items such as scraper traps, manifolds, volume chambers, etc., shall be hydrostatically tested to limits equal to or greater than those required of the completed system. This test may be conducted separately or as a part of this completed system.

b) In testing fabricated items before installation, the applicable sections of specifications listed in Table 4 shall apply.

10.2.1.2 Testing After New Construction

a) Systems or Parts of Systems

1) All liquid transportation piping systems within the scope of this Code, regardless of stress, shall be tested after construction.

2) System to be operated at a hoop stress of more than 20% of the specified minimum yield strength of the pipe shall be hydrostatically tested in accordance with section 10.2.2.1.

3) Systems to be operated at a hoop stress of 20% or less of specified minimum yield strength of the pipe may be subjected to a leak test in accordance with section 10.2.2.3 in lieu of the hydrostatic test specified in section 10.2.2.1.

4) When testing piping, in no case shall the test pressure exceed that stipulated in the standards of material specifications (except pipe) incorporated in this Code by reference and listed in Table 4 or the weakest element in the system or portion of system, being tested.

5) Equipment not to be subjected to test pressure shall be disconnected from the piping or otherwise isolated. Valves may be used if valve including closing mechanism is suitable for the test pressure.

b) Testing Tie-Ins. Because it is sometimes necessary to divide a pipeline into test sections and install test heads, connecting piping, and other necessary appurtenances for testing, or to install a pre-tested replacement section, it is not required that tie-in welds joining lengths of pretested pipe shall be inspected by radiographic or other accepted non-destructive methods in accordance with section 9.1.8.5 (a)(4) if system is not pressure tested after tie-in. After such inspection, the joint shall be coated and inspected in accordance with section 12.2.1.2 before backfilling.

c) Testing Controls and Protective Equipment. All controls and protective equipment, including pressure limiting devices, regulators, controllers, relief valves, and other safety devices, shall be tested to determine that they are in good mechanical condition, of adequate capacity, effectiveness, and reliability of operations for the service in which they are employed, functioning at the correct pressure; and properly installed and protected from foreign materials or other conditions that might prevent proper operation.

10.2.2 Test Pressure

10.2.2.1 Hydrostatic Testing of Internal Pressure Piping

a) Portions of piping systems to be operated at a hoop stress of more than 20% of the specified minimum yield strength of the pipe shall be subjected at any point to be hydrostatic proof test equivalent to not less than 1.25 times the internal design pressure at that point (see section 6.1.2.1) for not less than 4 hr. When lines are tested at pressures which develop a hoop stress, based on nominal wall thickness, in excess of 90% of the specified minimum
yield strength of the pipe, special care shall be used to prevent overstrain of the pipe.

1) Those portions of piping systems where all of the pressurized components are visually inspected during the proof test to determine that there is no leakage require no further test. This can include lengths of pipe which are pretested for use as replacement sections.

2) On those portions of piping systems not visually inspected while under test, the proof test shall be followed by a reduced pressure leak test equivalent to not less than 1.1 times the internal design pressure for not less than 4 hr.

b) API RP 1110 may be used for guidance for the hydrostatic test.

c) The hydrostatic test shall be conducted with water, except liquid petroleum that does not vaporize rapidly may be used provided:

1) the pipeline section under test is not offshore and is outside of cities and other populated areas, and each building within 100m (328 ft) of the test section is unoccupied while the test pressure is equal to or greater than a pressure which produces a hoop stress of 50% of the specific minimum yield stress of the pipe;

2) the test section is kept under surveillance by regular patrols during tests; and

3) communication is maintained along the test section.

d) If the testing medium in the system will be subject to thermal expansion during the test, provisions shall be made for relief of excess pressure. Effects of temperature changes shall be taken into account when interpretations are made of recorded test pressures.

e) After completion of the hydrostatic test, it is important that the lines, valves, and fittings be drained completely of any water.

10.2.2.2 Leak Testing

A 1 hr hydrostatic or pneumatic leak test may be used for piping systems to be operated at hoop stress of 20% or less of the specified minimum yield strength of the pipe. The hydrostatic test pressure shall be not less than 1.25 times the internal design pressure. The pneumatic test gauge pressure shall be 7 bar (100 psi) or that pressure which would produce a nominal hoop stress of 25% of the specified minimum yield strength of the pipe, whichever is less.

10.2.3 Qualification Test

Where tests are required by other sections of this Code, the following procedures shall be used.

10.2.3.1 Visual Examination.

Used or new pipe to be laid shall be visually examined in accordance with section 10.1.3.1.

10.2.3.2 Bending Properties

a) For pipe of unknown specification or ASTM A 120, bending properties are required if minimum yield strength used for design is above 165 MPa (24,000 psi), and after type of joint has been identified in accordance with section 3.7.6.4. For pipe NPS 2 and smaller, bending test shall meet the requirements of ASTM A 53 or API 5L. For pipe larger than NPS 2 in nominal diameter, flattening tests shall meet the requirements in ASTM A 53, API 5L, or API 5LU.

b) The number of tests required to determine bending properties shall be the same as required in section 10.2.3.6 to determine yield strength.

10.2.3.3 Determination of Wall Thickness
When the nominal wall thickness is not known, it shall be determined by measuring the thickness at quarter points on one end of each piece of pipe. If the lot of pipe is known to be of uniform grade, size, and nominal thickness, measurement shall be made on not less than 5% of the individual lengths, but not less than 10 lengths; thickness of the other lengths may be verified by applying a gauge set to the minimum thickness. Following such measurement, the nominal wall thickness below the average of all the measurement taken, but in no case greater than 1.14 times the least measured thickness for all pipe under NPS 20, and no greater than 1.11 times the least measured thickness for all pipe NPS 20 and larger.

10.2.3.4 Determination of Weld Joint Factor

If the type of longitudinal or spiral weld joint is known, the corresponding weld joint factor \( E \) (Table 2) may be used. Otherwise, as noted in Table 2, the factor \( E \) shall not exceed 0.60 for pipe NPS 4 and smaller, or 0.80 for pipe over NPS 4.

10.2.3.5 Weldability

For steel pipe of unknown specification, weldability shall be determined as follows. A qualified welder shall make a circumferential (girth) weld in the pipe. This weld shall be tested in accordance with the requirements of section 9.1.8.5. The qualifying weld shall be made under the most severe conditions under which welding will be permitted in the field and using the same procedure as to be used in the field. The pipe shall be considered weldable if the requirements set forth in section 9.1.8.5 are met. At least one such test weld shall be made for each number of lengths to be used as listed below:

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Number of Lengths Per Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 6</td>
<td>400</td>
</tr>
<tr>
<td>6 through 12</td>
<td>200</td>
</tr>
<tr>
<td>Larger than 12</td>
<td>100</td>
</tr>
</tbody>
</table>

All test specimens shall be selected at random.

10.2.3.6 Determination of Yield Strength

When the specified minimum yield strength, minimum tensile strength, or minimum percent of elongation of pipe is unknown, the tensile properties may be established as follows:

Perform all tensile tests prescribed by API 5L or 5LU, except that the minimum number of such tests shall be as follows:

<table>
<thead>
<tr>
<th>Nominal Pipe Size (NPS)</th>
<th>Number of Lengths Per Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 6</td>
<td>200</td>
</tr>
<tr>
<td>6 through 12</td>
<td>100</td>
</tr>
<tr>
<td>Larger than 12</td>
<td>50</td>
</tr>
</tbody>
</table>

All test specimens shall be selected at random.

10.2.3.7 Minimum Yield Strength Value

For pipe of unknown specification, the minimum yield strength may be determined as follows.
Average the value of all yield strength tests for a test lot. The minimum yield strength shall then be taken as the lesser of the following:

a) 80% of the average value of the yield strength tests;

b) The minimum value of any yield strength test except that in no case shall this value be taken as greater than 358 MPa (52,000 psi);

c) 165 MPa (24,000 psi) if the average yield-tensile ratio exceeds 0.85.

10.2.4 Records

A record shall be maintained in the files of the operating company relative to design, construction, and testing of each transportation piping system within the scope of this Code. These records shall include material specifications; route maps and alignments sheets for “as-built” condition; location of each pipe size, grade, wall thickness, type, specification, and manufacturer; coatings; and test data. These records shall be kept for the life of the facility. See section 10.1.3.1(a)(3).

11.0 OPERATION AND MAINTENANCE PROCEDURES

11.1 OPERATION AND MAINTENANCE PROCEDURES AFFECTING THE SAFETY OF LIQUID HYDROCARBON TRANSPORTATION PIPING SYSTEMS

11.1.1 General

a) It is not possible to prescribe in this Code a detailed set of operating and maintenance procedures that will encompass all cases. It is possible, however, for each operating company to develop operating and maintenance procedures based on the provisions of this Code, and the company’s experience and knowledge of its facilities and conditions under which they are operated, which will be adequate from the standpoint of public safety.

b) The methods and procedures set forth herein serve as a general guide, but do not relieve the individual or operating company from the responsibility for prudent action that current particular circumstances make advisable.

c) It must be recognized that local conditions (such as the effects of temperature, characteristics of the line content, and topography) will have considerable bearing on the approach to any particular maintenance and repair job.

d) Suitable safety equipment shall be available for personnel use at all work areas and operating facilities.

11.1.2 Operation and Maintenance Plans and Procedures

Each operating company having a transportation piping system within the scope of this Code shall:

a) have written detailed plans and training programs for employees covering operating and maintenance procedures for the transportation piping system during normal operations and maintenance in accordance with the purpose of this Code; essential features recommended for inclusion in the plans for specific portions of the system are given in section 11.2 and 11.3;

b) have a plan for external and internal corrosion control of new and existing piping systems, including requirements and procedures prescribed in section 11.4 and Clause 12.0;

c) have a written emergency plan as indicated in section 454 for implementation in the event of system failures, accidents, or other emergencies; train appropriate operating and maintenance employees with regard to applicable portions of the plan, and establish liaison with appropriate public officials with respect to the plan;

d) have a plan for reviewing changes in conditions affecting the integrity and safety of the piping system, including
provisions for periodic patrolling and reporting of construction activity and changes in conditions, especially in industrial, commercial, and residential areas and at river, rail, and road crossings, in order to consider the possibility of providing additional protection to prevent damage to the pipeline in accordance with section 6.2.1;

e) establish liaison with relevant authorities who issue construction permits in urban areas to prevent accidents caused by excavators;

f) establish procedures to analyze all failures and accidents for the purpose of determining the cause and to minimize the possibility of recurrence;

g) maintain necessary maps and records to properly administer the plans and procedures, including records listed in section 11.6;

h) have procedures for abandoning piping systems, including the requirements in section 11.8.

i) in establishing plans and procedures, give particular attention to those portions of the system presenting the greatest hazard to the public in the event of emergencies or because of construction or extraordinary maintenance requirements;

j) operate and maintain its piping system in conformance with these plans and procedures;

k) modify the plans and procedures from time to time as experience dictates and as exposure of the system to the public and changes in operating conditions require.

11.2 PIPELINE OPERATION AND MAINTENANCE

11.2.1 Operating Pressure

a) Care shall be exercised to assure that at any point in the piping system the maximum steady state operating pressure and static head pressure with the line in a static condition do not exceed at the point the internal design pressure and pressure ratings for the components used as specified in section 6.2.2.3, and that the level of pressure rise due to surges and other variations from normal operation does not exceed the internal design pressure at any point in the piping system and equipment by more than 10% as specified in section 6.2.2.4.

b) A piping system shall be qualified for a higher operating pressure when the high operating pressure will produce a hoop stress or more than 20% of the specified minimum yield strength of the pipe in accordance with section 11.7.

c) If a piping system is derated to a lower operating pressure in lieu of repair or replacement, the new maximum steady state operating pressure shall be determined in accordance with section 11.2.7.

d) For existing system utilizing materials produced under discontinued or superseded standards or specifications, the internal design pressure shall be determined using the allowable stress and design criteria listed in the issue of the applicable code or specification in effect at the time of the original construction.

11.2.2 Communications

A communications facility shall be maintained to assure safe pipeline operations under both normal and emergency conditions.

11.2.3 Markers

a) Markers shall be installed over each line on each side of road, highway, railroad, and stream crossings to properly locate and identify the system. Markers are not required for pipelines offshore.

b) Pipeline markers at crossings, aerial markers when used, and other signs shall be maintained so as to indicate the location of the line. These markers shall show the name of the operating company, and, where possible, an
emergency telephone contact. Additional pipeline markers shall be installed along the line in areas of development and growth to protect the system from encroachment. API RP 1109 shall be used for guidance.

11.2.4 Right of Way Maintenance

a) The right of way shall be maintained so as to have clear visibility and to give reasonable access to maintenance crews.

b) Access shall be maintained to valve locations.

c) Diversion ditches or dikes shall be maintained where needed to protect against washouts of the line and erosion of the landowner’s property.

11.2.5 Patrolling

a) Each operating company shall maintain a periodic pipeline patrol program to observe surface conditions on and adjacent to the pipeline right of way, indication of leaks, construction activity other than that performed by the company, and any other factors affecting the safety and operation of the pipeline. Special attention shall be given to such activities as road building, ditch cleanouts, excavations, and like encroachments to the pipeline system. Patrols shall be made at intervals not exceeding 2 weeks, except that piping system transporting LPG shall be patrolled at intervals not exceeding 1 week in industrial, commercial, or residential areas.

b) Underwater crossings shall be inspected periodically for sufficiency of cover, accumulation of debris, or for any other condition affecting the safety and security of the crossings, and at any time it is felt that the crossings are in danger as a result of floods, storms, or suspected mechanical damage.

11.2.6 Pipeline Repairs

11.2.6.1 General

Repairs shall be covered by a maintenance plan (see section 11.1.2(a)) and shall be performed under qualified supervision by trained personnel aware of and familiar with the hazards to public safety, utilizing strategically located equipment and repair materials. The maintenance plan shall consider the appropriate information contained in API Publ. 2200, API Publ. 2201, API RP 1107, and API RP 1111. It is essential that all personnel working on pipeline repairs understand the need for careful planning of the job, be briefed as to the procedure to be followed in accomplishing the repairs, and follow precautionary measures and procedures outlined in API Publ. 2200. Personnel working on repairs to pipelines handling LPG or liquid alcohol shall also be informed on the specific properties, characteristics, and potential hazards associated with those liquids; precautions to be taken following detection of a leak and safety repair procedures set forth for LPG pipelines in API Publ. 2201 shall be observed for welding, as well as making hot taps on pipelines, vessels, or tanks which are under pressure. Piping in the vicinity of any repair shall be adequately supported during and after the repair.

11.2.6.2 Disposition of Defects

a) Limits and Disposition of Imperfections

1) Gouges and grooves having a depth greater than 12½% of the nominal wall thickness shall be removed or repaired.

2) Dents meeting any of the following conditions shall be removed or repaired;

(b) dents which affect the pipe curvature at the pipe seam or at any circumferential (girth) weld;

(c) dents containing a scratch, gouge, or groove; or

(d) dents exceeding a depth of 6mm. (¼ in) in pipe NPS 4 and smaller, or 6% of the nominal pipe diameter in sizes greater than NPS 4
3) All arc burns shall be removed or repaired.

4) All cracks shall be removed or repaired.

5) All welds found to have defects as set forth in section 9.1.8.5(b) or in the appropriate pipe specification shall be removed or repaired.

6) General Corrosion. Pipe shall be replaced, or repaired if the area is small, or operated at a reduced pressure (see section 11.2.7) if general corrosion has reduced the wall thickness to less than the design thickness calculated in accordance with section 6.4.1.2 decreased by an amount equal to the manufacturing tolerance applicable to the pipe or component. - Recast

7) Localised Corrosion Pitting. Pipe shall be repaired, replaced, or operated at a reduced pressure (see section 11.2.7) if localized corrosion pitting has reduced the wall thickness to less than the design thickness calculated in accordance with section 6.4.1.2 decreased by an amount equal to the manufacturing tolerance applicable to the pipe or component. This applies if the length of the pitted area is greater than permitted by the equation shown below. The following method applies only when the depth of the corrosion pit is less than 80% of the nominal wall thickness of the pipe. This method does not apply to corrosion in the circumferential (girth) or longitudinal weld or related heat affected zones. The corroded area must be clean to bare metal. Care shall be taken in cleaning corroded areas of a pressurised pipeline when the degree of corrosion is significant.

\[
L = 1.12B \sqrt{Dt_c}
\]

Where

\[
B = \sqrt{\frac{\frac{c}{t_c}}{\frac{1.1c}{t_c} + 0.1}}
\]

\[
L = \text{Maximum allowable longitudinal extent of the corroded area as shown in Fig. 11, in. (mm)}
\]

\[
B = \text{a value not to exceed 4.0 which may be determined from the above equation or Fig. 11}
\]

\[
D = \text{nominal outside diameter of the pipe, in. (mm)}
\]

\[
t_c = \text{nominal outside wall thickness of the pipe, in. (mm)}
\]

\[
c = \text{maximum depth of the corroded area, in. (mm)}
\]

8) Areas where grinding has reduced the remaining wall thickness to less than the design thickness calculated in accordance with section 6.4.1.2 decreased by an amount equal to the manufacturing tolerance applicable to the pipe or component, may be analyzed the same as localized corrosion pitting (see section 11.2.6.2(a) (7) to determine if ground areas need to be replaced, repaired, or the operating pressure reduced (see section 11.2.7). ANSI/ASME B31.3 may be used for guidance.

9) All pipe containing leaks shall be removed or repaired.

b) Allowable Pipeline Repairs

1) If practical, the pipeline should be taken out of service and repaired by cutting out a cylindrical piece of pipe containing the defect and replacing the same with pipe meeting the requirements of section 6.1.2.1 and having a
length of not less than one-half diameter.

2) If not practical to take the pipeline out of service, repairs may be made by the installation of a full encirclement welded or mechanically applied split sleeve in accordance with section 11.2.6.2(c).

   (a) For repairs of dents, either a hardenable filler material such as epoxy shall be used to fill the void between the sleeve and the pipe to restore the original contour of the pipe, or the carrier pipe shall be tapped through the sleeve or other means provided to equalize the internal pressure of the carrier pipe and the sleeve.
   (b) For repairs to non-leaking cracks, the carrier pipe shall be tapped through the pressure containing sleeve or other means provided to equalize the internal pressures of the carrier pipe and the sleeve.

3) If not practical to take the pipeline out of service, defects may be removed by grinding or hot tapping. When grinding, the ground areas shall be smoothly contoured and be in accordance with section 11.2.6.2(a)(8). When not tapping, the portion of piping containing the defect shall be completely removed.

4) If not practical to take the pipeline out of service, minor leaks and small corroded areas, except for cracks, may be repaired by the installation of a patch or welded fitting in accordance with section 11.2.6.2(c)(5) and (8). Pipe containing arc burns, grooves, and gouges may be repaired with patches or welded fitting if the arc burn or notch is removed by grinding.

5) If not practical to take the pipeline out of service, defects in welds produced with a filler metal, small corroded areas, gouges, grooves, and arc burns may be repaired by depositing weld metal in accordance with section 11.2.6.2(c)(9). Weld imperfections, arc burns, gouges, and grooves shall be removed by grinding prior to depositing the weld filler metal.

6) If not practical to take the pipeline out of service, non-leaking corroded areas may be repaired by installation of a fully welded, partial encirclement half sole in accordance with section 11.2.6.2(c)(13).

c) Repair Methods

1) All repair weld procedures and all welders performing repair work shall be qualified in accordance with section 9.1.8.3 or API RP 1107. The welders shall also be familiar with safety precautions and other problems associated with cutting and welding on pipe that contains or has contained liquids within the scope of this Code. Cutting and welding shall commence only after compliance with section 9.1.8.1.(c).

2) The qualification test for welding procedures to be used on pipe containing a liquid shall consider the cooling effects of the pipe contents on the soundness and physical properties of the weld. Welding procedures on pipe not containing liquid shall be qualified in accordance with section 9.1.8.3.

3) Materials used for pipeline repair shall be in accordance with at least one of the specifications or standards listed in Table 4, or as otherwise required by this Code.

4) Temporary repairs may be necessitated for operating purposes and shall be made in a safe manner. Such temporary repairs shall be made permanent or replaced in a permanent manner as described herein as soon as practical.

5) Welded patches shall have rounded corners and a maximum dimension of 6 in. (150 mm) along the pipe axis. The patch material shall be of a similar or higher grade with a wall thickness similar to the pipe being repaired. Patches shall be limited to pipe sizes NPS 12 and less and conforming to API 5L, Grade X42 and lower. Patches shall be attached by fillet welds. Insert patching is prohibited. Special consideration shall be given to minimize stress concentrations resulting from the repair.
Figure 11. Parameters used in analysis of the strength of corroded areas

6) Full encirclement welded split sleeves installed to repair leaks or otherwise to contain internal pressure shall have a design pressure of not less than the pipe being repaired and shall be fully welded, both circumferentially and longitudinally. Length of full encirclement split sleeves shall not be less than 100 mm (4 in.). If the sleeve is thicker than the pipe being repaired, the circumferential ends shall be chamfered (at approximately 45 degrees) down the thickness of the pipe. For full encirclement split sleeves installed for repair by reinforcement only and not internal pressure containment, circumferential welding is optional. Special consideration shall be given to minimise stress concentrations resulting from the repair.

7) Mechanically applied full encirclement repair fittings shall meet the design requirements of sections 6.1.2 and 6.13.

8) Welded fittings used to cover pipeline defects shall not exceed NPS 3 and shall have a design pressure of
not less than the pipe being repaired.

9) For repairs involving only deposition of a weld filler metal, welding processes shall be in accordance with the requirements of the appropriate pipe specification for the grade and type being repaired. Welding procedure qualifications shall be in accordance with section 11.2.6.2.(c)(2).

10) Where repairs are made to a coated pipe, all damaged coating shall be removed and new coating applied in accordance with section 12.2.1.2. Replacement pieces of pipe, welded patches, and full encirclement welded split sleeves used in making repairs shall also be coated when installed in a coated line.

11) Pipe containing liquid shall be examined to determine that the material is sound and of adequate thickness in the areas to be affected by grinding, welding, cutting, or hot tapping operations.

12) If the pipeline is not taken out of service, the operating pressure shall be reduced to a level which will provide safety during the repair operations.

13) Fully welded partial encirclement half soles may be used to repair corroded areas only on pipe and shall not be used to repair leaks, gouges, dents, or other defects. The use of half soles shall be limited to pipe sizes NPS 12 or less and may only be used on pipe made prior to 1942 with a specified minimum yield strength not exceeding 276 MPa (40,000 psi). The half sole material shall be of a similar or higher grade with a wall thickness not less than 87.5% or more than 125% of that of the pipe being repaired. Half soles shall have rounded corners and a maximum length of 10 ft (3 m) along the pipe axis. Half soles shall not be used across circumferential (girth) welds and the minimum clearance between the end of half soles or the ends of half soles and circumferential (girth) welds shall be 50 mm (2 inches). Combinations of a half sole and patches shall not be used in parallel around a given circumference. To ensure optimum performance of half soles, the annular space between the corroded pipe and the half sole may be filled with a hardenable filler material such as epoxy. Special consideration shall be given to ensuring a close fit between the edge of the half sole and the pipe being repaired and to minimizing stress concentrations resulting from the repair.

11.2.6.3 Testing Repairs to Pipelines Operating at a Hoop Stress of More Than 20% of the Specified Minimum Yield Strength of the Pipe

a) Testing of Replacement Pipe Sections. When a scheduled repair to a pipeline is made by cutting out a section of the pipe as a cylinder and replacing it with another section of pipe, the replacement section of pipe shall be subjected to a pressure test. The replacement section of pipe shall be tested as required for a new pipeline in accordance with section 10.2.2.1. The tests may be made on the pipe prior to installation provided radiographic or other acceptable nondestructive tests (visual inspection excepted) are made on all tie-in butt welds after installation.

b) Examination of Repair Welds. Welds made during pipeline repairs shall be examined by accepted nondestructive methods or visually examined by a qualified inspector.

11.2.7 Derating a Pipeline to a lower Operating Pressure

a) Corroded pipe or pipe containing areas repaired by grinding may be derated to a lower operating pressure in lieu of replacement or repair or further repair. Except as provided in section 11.2.7(b), the lower operating pressure shall be based on section 6.4.1.2 and the actual remaining wall thickness of the pipe at the point of deepest corrosion or grinding.

b) For pipe containing localized corrosion pitting or areas repaired by grinding where the remaining material in the pipe does not meet the depth and length limits in section 11.2.6.2(a)(7), the lower operating pressure may be determined by the following equation, provided the corrosion or grinding is not in the circumferential (girth) or longitudinal weld or related heat affected zones.
\[ P_d = 1.1 P_i \]

Where

\[ G = \frac{0.893}{\sqrt{Dt_n}} \]

is a value not to exceed 4.0 in the above analysis and which may be determined from the above equation.

\[ P_d = \text{derated internal design gauge pressure, bar (psi).} \]

\[ P_i = \text{original internal design gauge pressure, based on specified nominal wall thickness of the pipe (see section 6.4.1), bar (psi).} \]

\[ L = \text{longitudinal extent of the corroded area as shown in Fig. 11, in. (mm)} \]

For \( t_n, c, \) and \( D, \) see section 11.2.6.2(a)(7).

For values of \( G \) greater than 4.0,

\[ P_d = 1.1 P_i (1 - c/t_n) \]

Except \( P_d \) shall not exceed \( P_i. \)

11.2.8 Valve Maintenance

Pipeline block valves shall be inspected, serviced where necessary, and partially operated at least once each year to assure proper operating conditions.

11.2.9 Rail and Road Crossings Existing Pipelines

a) When an existing pipeline is to be crossed by a new road or rail, the operating company shall reanalyze the pipeline in the area to be crossed in terms of the new anticipated external loads. If the sum of the circumferential stresses caused by internal pressure and newly imposed external loads exceeds 0.72 SMYS (specific minimum yield strength) by more than 25%, the operating company shall install mechanical reinforcement, structural protection, or suitable pipe to reduce the stress or redistribute the external loads acting on the pipeline. API RP 1102 provides methods which may be used to determine the total stress caused by internal pressure and external loads.

b) Installation of uncased carrier pipe is preferred. Adjustments of existing pipelines in service at a proposed railroad or highway crossing shall conform to details contained in API RP 1102. as specified in section 12.2.1.2.(f), if casing is used, coated carrier pipe shall be independently supported outside each end of the casing and insulated from the casing throughout the cased section, and casing ends shall be sealed using a durable, electrically non-conductive material.

c) Testing and inspection of replaced pipe sections shall conform to requirements of section 451.6.3. All new circumferential (girth) welds in the carrier pipe shall be radiographed or inspected by other acceptable non-destructive methods (visual inspection excepted).

11.2.10 Platform Risers

Riser installations shall be visually inspected annually for physical damage and corrosion in the splash zone and
above. The extent of any observed damage shall be determined, and, if necessary, the riser installation shall be repaired or replaced.

11.3 PUMP STATION, TERMINAL, AND TANK FARM OPERATION AND MAINTENANCE

11.3.1 General

a) Starting, operating, and shutdown procedures for all equipment shall be established and the operating company shall take appropriate steps to see that these procedures are followed. These procedures shall outline preventive measures and systems checks required to ensure the proper functioning of all shutdown, control, and alarm equipment.

b) Periodic measurement and monitoring of flow and recording of discharge pressures shall be provided for detection of deviations from the steady state operating conditions of the system.

11.3.2 Controls and Protective Equipment

a) Controls and protective equipment, including pressure limiting devices, regulators, controllers, relief valves, and other safety devices, shall be subjected to systematic periodic inspections and tests, at least annually, except as provided in section 11.3.2(b), to determine that they are:

1) in good mechanical condition;

2) adequate from the standpoint of capacity and reliability of operation for the service in which they are employed;

3) set to function at the correct pressure;

4) properly installed and protected from foreign materials or other conditions that might prevent proper operation.

b) Relief valves on pressure storage vessels contained LPG shall be subjected to tests at least every 5 years.

11.3.3 Storage Vessels

a) Storage vessels, including atmospheric and pressure tanks, handling the liquid or liquids being transported shall be periodically inspected and pertinent records maintained. Points to be covered include:

1) stability of foundation;

2) condition of bottom, shell, stairs, roof;

3) venting or safety valve equipment;

4) condition of firewalls or tank dikes.

b) Storage vessels and tanks shall be cleaned in accordance with API Publ. 2015 and ZS 604 Part 2.

11.3.4 Storage of Combustible Materials

All flammable or combustible materials in quantities beyond those required for everyday use or other than those normally used in pump houses shall be stored in a separate structure built of noncombustible material located a suitable distance from the pump house. All above ground oil or gasoline storage tanks shall be protected in accordance with ZS 385 Part 1 and ANSI/NFPA 30.
11.3.5 Fencing

Station, terminal, and tank farm areas shall be maintained in a safe condition, and shall be fenced and locked, or attended, for the protection of the property and the public.

11.3.6 Signs

a) Suitable signs shall be posted to serve as warnings in hazardous areas.
b) Classified and high voltage areas shall be adequately marked and isolated.
c) Caution signs shall be displayed indicating name of the operating company and, where possible, an emergency telephone contact.

11.3.7 Prevention of Accidental Ignition

a) Smoking shall be prohibited in all areas of a pump station, terminal, or tank farm in which the possible leakage or presence of vapour constitutes a hazard of fire or explosion.
b) Flashlights or hand lanterns, when used, shall be in accordance with ZS 402/refinery standards of the approved type.
c) Welding shall commence only after compliance with section 9.1.8.1(c).
d) Consideration should be given to the prevention of other means of accidental ignition. See NACE RP-01-77 for additional guidance.

11.4 CORROSION CONTROL

Protection of ferrous pipe and components from external and internal corrosion, including tests, inspections, and appropriate corrective measures, shall be as prescribed in Clause 12.0.

11.5 EMERGENCY PLAN

a) A documented emergency plan shall be established for implementation in the event of system failures, accidents, or other emergencies, and shall include procedures for prompt and expedient remedial action providing for the safety of the public and operating company personnel, minimising property damage, protecting the environment, and limiting accidental discharge from the piping system.
b) The plan shall provide for acquainting and training of personnel responsible for the prompt execution of emergency action. Personnel shall be informed concerning the characteristics of the liquid in the piping system and the safe practices in the handling of accidental discharge and repair of the facilities, with emphasis on the special problems and additional precautions in the handling of leaks and repair of systems transporting LPG. The operating company shall establish scheduled review with personnel of procedures to be followed in emergencies at intervals not exceeding 6 months, and reviews shall be conducted such that they establish the competence of the emergency plan.
c) Procedures shall cover liaison with state and local civil agencies such as fire departments and police departments etc, to provide prompt intercommunications for coordinate remedial action; dissemination of information on location of system facilities; characteristics of the liquid transported, including additional precautions necessary with leaks from piping systems transporting LPG; and joint preparation of cooperative action as necessary to assure the safety of the public in the event of emergencies.
d) A line of communication shall be established with residents along the piping system to recognise and report a system emergency to the appropriate operating company personnel. This could include supplying a card, sticker, or equivalent with names, addresses, and telephone numbers of operating company personnel to be contacted.
In the formulation of emergency procedures for limiting accidental discharge from the piping system, the operating company shall give consideration to:

1) formulating and placing in operation, procedures for an area cooperative pipeline leak notification emergency action system between operating companies having piping systems in the area;

2) reduction of pipeline pressure by ceasing pumping operations on the piping system, opening the system to delivery storage on either side of the leak site, and expeditious closing of block valves on both sides of the leak site, and in the case of systems transporting LPG, continuation of pumping until LPG has been replaced at point of leak by a less volatile product if vapours are not accumulating to an extent that a serious hazard appears imminent;

3) interim instructions to local authorities prior to arrival of qualified operating company personnel at the leak site;

4) rapid transportation of qualified personnel to the leak site;

5) minimisation of public exposure to injury and prevention of accidental ignition by evacuation of residents and the halting of traffic on roads, highways, and railroads in the affected area;

6) in the case of systems transporting LPG, assessment of extent and coverage of the LPG vapour cloud and determination of hazardous area with portable explosimeters; ignition of vapours at leak site to prevent the uncontrolled spread of vapours; utilization of temporary flares or blow downs on either side of the leak site, and utilization of internal plugging equipment where it is anticipated that vapourisation of LPG entrapped in pipeline segment will continue over a prolonged period.

11.6 RECORDS

For operation and maintenance purposes, the following records shall be properly maintained:

a) necessary operational data;

b) pipeline patrol records;

c) corrosion records as required under section 12.5;

d) leak and break records;

e) records relating to routine or unusual inspections, such as external or internal line conditions when cutting line or hot tapping;

f) pipeline repair records.

11.7 QUALIFYING A PIPING SYSTEM FOR A HIGHER OPERATING PRESSURE

a) In the event of up-rating an existing piping system when the higher operating pressure will produce a hoop stress of more than 20% of the specified minimum yield strength of the pipe, the following investigative and corrective measures shall be taken:

1) the design and previous testing of the piping system and the materials and equipment in it be reviewed to determine that the proposed increase in maximum steady state operating pressure is safe and in general agreement with the requirements of this Code;

2) the conditions of the piping system be determined by leakage surveys and other field inspections, examination of maintenance and corrosion control records, or other suitable means;
3) repairs, replacements, or alterations in the piping system disclosed to be necessary by steps (1) and (2) be made.

b) The maximum steady state operating pressure may be increased after compliance with (a) above and one of the following provisions.

1) If the physical condition of the piping system as determined by (a) above indicates that the system is capable of withstanding the desired increased maximum steady state operating pressure in accordance with the design requirement of this Code, and the system has previously been tested for a duration and to a pressure equal to or greater than required in sections 10.2.2 (a) and (c) for a new piping system for the proposed higher maximum steady state operating pressure, the system may be operated at the increased maximum steady state operating pressure.

2) If the physical condition of the piping system as determined by (a) above indicates that the ability of the system to withstand the increased maximum steady state operating pressure has not been satisfactorily verified, or the system has not been previously tested to the levels required by this Code for a new piping system for the proposed higher maximum steady state operating pressure, the system may be operated at the increased maximum steady state operating pressure if the system shall successfully withstand the test required by this Code for a new system to operate under the same conditions.

c) In no case shall the maximum steady state operating pressure of a piping system be raised to a value higher than the internal design pressure permitted by this Code for a new piping system constructed of the same materials. The rate of pressure increase to the higher maximum allowable steady state operating pressure should be gradual so as to allow sufficient time for periodic observations of the piping system.

d) Records of such investigations, work performed and pressure tests conducted shall be preserved as long as the facilities involved remain in service.

11.8 ABANDONING A PIPING SYSTEM

In the event of abandoning a piping system, it is required that:

a) Facilities to be abandoned in place shall be disconnected from all sources of the transported liquid, such as other pipelines, meter stations, control lines, and other appurtenances;

b) Facilities to be abandoned in place shall be purged of the transported liquid and vapour with an inert material and the end sealed.

c) Such abandoned pipe waste shall be disposed of in accordance with existing legislation.

12.0 CORROSION CONTROL

12.1 GENERAL

a) This Chapter prescribes minimum requirements and procedures for protection of ferrous pipe and components from external and internal corrosion, and is applicable to new piping installations and existing piping system.

b) External and internal corrosion shall be controlled consistent with condition of the piping system and the environment in which the system is located by application of these corrosion control requirements and procedures. Application of some corrosion control practices requires a significant amount of competent judgment in order to be effective in mitigating corrosion, and deviation from the provision of this Chapter is permissible in specific situations, provided the operating company can demonstrate that the objectives expressed herein have achieved.

c) Corrosion control requirements and procedures may in many instances require measures in addition to those
shown herein. Therefore, each operating company shall establish procedures to implement the requirements of this Chapter. Procedures, including those for design, installation, and maintenance of cathodic protection systems, shall be prepared and carried out by, or under the direction of, persons qualified by training or experience in corrosion control methods. NACE RP-01-69 or NACE RP-06-75 provides a guide for procedures to implement requirements herein and to monitor and maintain cathodic protection systems.

d) Corrosion personnel shall be provided with equipment and instrumentation necessary to accomplish the work.

e) Coating crews and inspectors shall be suitably instructed and provided with equipment necessary to coat and inspect the pipe and components.

12.2 EXTERNAL CORROSION CONTROL FOR BURIED OR SUBMERGED PIPELINES

12.2.1 New Installations

12.2.1.1 General

a) Control of external corrosion of new buried or submerged piping systems shall be provided for each component in the system except where the operating company can demonstrate by tests, investigations, or experience in the area of application that a detrimental corrosive environment does not exist. However, within 12 months after installation, the operating company shall electrically inspect the buried or submerged system. If the electrical inspection indicates that a corrosive condition exists, the piping system shall be cathodically protected. If cathodic protection is not installed, the piping system shall be electrically inspected at intervals not exceeding 5 years, and the system shall be cathodically protected if electrical inspection indicates that a corrosive condition exists.

b) Control of external corrosion of buried or submerged pipe and components in new installations (including new pump stations, tank farms, and terminals, and relocating, replacing, or otherwise changing existing piping systems) shall be accomplished by the application of an effective protective coating supplemented with cathodic protection and suitable drainage bonds in stray current areas. Materials shall be selected with due regard to the type of supplemental corrosion protection and to the environment.

c) For piping systems offshore, special attention shall be given to control external corrosion of the pipeline risers in the “splash” zone.

d) Where impractical, and where adequate provisions for corrosion control have been made, the minimum clearance of 300 mm (12 in.) between the outside of any pipe installed underground and the extremity of any other underground structure specified in section 9.1.6(c) may be reduced.

12.2.1.2 Protective Coating

a) Protective coatings used on buried or submerged pipe and components shall have the following characteristics:

1) mitigate corrosion;

2) have sufficient adhesion to the metal surface to effectively resist underfilm migration of moisture;

3) be ductile enough to resist cracking;

4) have strength sufficient to resist damage due to handling and soil stress;

5) have properties compatible with any supplemental cathodic protection.

b) Welds shall be inspected for irregularities that could protrude through the pipe coating, and any such irregularities shall be removed.
c) Pipe coating shall be inspected, both visually and by an electric holiday detector, just prior to: lowering pipe into ditch, applying a weight coating if used, or submerging the pipe if no weight coating is used. Any holiday or other damage to the coating detrimental to effective corrosion control shall be repaired and reinspected.

d) Insulating pipe coating, if used, shall have low moisture absorption characteristics and provide high electrical resistance. Insulating coating shall be inspected in accordance with established practices at the time of application and just prior to lowering pipe into ditch, and defects shall be repaired and reinspected.

e) Pipe shall be handled and lowered into ditch or submerged so as to prevent damage after the electrical inspection. Pipe coating shall be protected from lowering-in damage in rough or detrimental environment by use of rock shield, ditch padding, or any other suitable protective measures.

f) If coated pipe is installed by boring, driving, or other similar method, precautions shall be taken to minimize damage to the coating during installation. If casing is used (see section 9.1.13.4 and 11.2.9), carrier pipe shall be independently supported outside each end of the casing, and insulated from the casing throughout the length of cased section, and casing ends shall be sealed using a durable, electrically non-conductive material.

g) The backfilling operation shall be inspected for quality, compaction, and placement of material to prevent damage to pipe coating.

h) Where a connection is made to a coated pipe, all damaged coating shall be removed and new coating applied on the attachments as well as on the pipe.

12.2.1.3 Cathodic Protection System

a) A cathodic protection system provided by a galvanic anode or impressed current anode system shall be installed that will mitigate corrosion and contain a method of determining the degree of cathodic protection achieved on the buried or submerged piping system.

b) A cathodic protection system shall be installed not later than 1 year after completion of construction.

c) Cathodic protection shall be controlled so as not to damage the protective coating, pipe, or components.

d) Owners of known underground structures which may be affected by installation of a cathodic protection system shall be notified of said installation, and, where necessary, joint bonding surveys shall be conducted by parties involved.

e) Electrical installations shall be made in accordance with the National Electrical Code, ANSI/NFPA 70, API 500C, and applicable local codes.

12.2.1.4 Electrical Isolation

a) Buried or submerged coated piping systems shall be electrically isolated at all interconnections with foreign systems, except where arrangements are made for mutual cathodic protection or where underground metallic structures are electrically interconnected and cathodically protected as a unit.

b) An insulating device shall be installed where electrical isolation of a portion of a piping system from pump stations, storage tanks, and similar installations is necessary to facilitate the application of corrosion control. The insulating device shall not be installed where a combustible atmosphere is anticipated unless precautions are taken to prevent arcing.

c) Consideration shall be given to the prevention of damage to piping systems due to lightning or fault currents when installed in close proximity to electric transmission tower footings, ground cables, or counterpoise. See NACE RP-01-77 for guidance when ac interference problems are suspected. Studies in collaboration with the operator of such electric transmission systems shall be made on common problems of corrosion and electrolysis.
d) Electrical tests shall be made to locate any unintentional contacts with underground metallic structures, and, if such contacts exist, each one shall be corrected.

e) When a pipeline is separated, a bonding conductor of sufficient current carrying capacity shall be installed across the points of separation and retained during the period of separation.

12.2.1.5 Test Leads

a) Except where impractical on piping systems offshore or in wet marsh areas, sufficient test leads shall be installed on all buried or submerged coated piping systems for taking electrical measurements to indicate adequacy of the cathodic protection.

b) Test leads shall be installed as follows.

1) Special attention shall be given to the manner of installation of test leads used for corrosion control or testing, and leads shall be attached to the pipe in such manner as to minimise stress and prevent surface cracks in the pipe. Leads may be attached directly on the pipe with the low temperature welding process using aluminum powder and copper oxide and limiting the charge to a 15g cartridge, or with soft solders or other materials that do not involve temperatures exceeding those for soft solders.

2) Slack shall be provided to prevent test leads from being broken or damaged during backfilling.

3) Leads shall be insulated from the conduit in which they are contained.

4) Bond points shall be made watertight, and bare test lead wires, pipe, and components shall be protected by electrical insulating material compatible with original wire insulation and pipe coating.

12.2.1.6 Electrical Interference

a) If an impressed current type cathodic protection system is used, the anodes shall be located so as to minimise adverse effect on existing underground metallic structures.

b) The possibility of external corrosion induced by stray electrical currents in the earth shall be recognized. See NACE RP-01-69 and NACE RP-01-77 for additional guidance. These stray currents are generated by sources remote from, and independent of, the piping system, and are more predominant in highly industrialized areas, mining regions, and locales containing high voltage dc electrical power ground beds. Foreign company pipeline cathodic protection systems are also a common source of stray earth currents. The protection of the piping system against stray current induced corrosion shall be provided by metallic bonds, increased cathodic protection, supplemental protection coatings, insulating flanges, or galvanic anodes.

12.2.2 Existing Piping Systems

The operating company shall establish procedures for determining the external condition of its existing buried or submerged piping systems and take action appropriate for the conditions found, including, but not limited to, the following.

a) Examine and study records available from previous inspections and conduct additional inspections where the need for additional information is indicated. The type, location, number, and frequency of such inspections shall be determined by consideration of such factors as knowledge of the condition of the piping system and environment, and public or employee safety in the event of leakage. Corrective measures shall be in accordance with section 12.5.

b) Install cathodic protection on all buried or submerged piping systems that are coated with an effective external surface coating material, except at pump stations, tank farms, and terminals. All buried or submerged piping at pump stations, tank farms, and terminals shall be electrically inspected and cathodic protection installed or augmented where necessary.
c) Operating pressures on bare piping systems shall not be increased until they are electrically inspected and other appropriate actions are taken regarding condition of pipe and components. The requirements of section 11.7 shall also be complied with in the event of up-rating.

12.2.3 Monitoring

a) Cathodic protection facilities for new or existing piping systems shall be maintained in a serviceable condition, and, except where impractical on systems offshore, electrical measurements and inspections of cathodically protected buried or submerged piping systems, including tests for stray electrical currents, shall be conducted at least each calendar year, but with intervals not exceeding 15 months, to determine that the cathodic protection system is operating properly and that all buried or submerged piping is protected in accordance with applicable criteria. Appropriate corrective measures shall be taken where tests indicate that adequate protection does not exist.

b) Evidence of adequate level of cathodic protection shall be by one or more of the criteria listed in Criteria for Cathodic Protection, Section 6 in NACE RP-01-69, or Section 3 in NACE RP 06-75.

c) The type, number, location, and frequency of tests shall be adequate to establish with reasonable accuracy the degree of protection provided on all piping within the limits of each cathodic protection system, and shall be determined by considering:

1) age of the piping system and operating experience, including bell hole inspection and leakage survey data;
2) condition of pipe at time of application of cathodic protection and method of applying protections;
3) corrosiveness of environment;
4) probability of loss of protection due to activity of other construction, reconstruction, or other causes in the area;
5) method of applying cathodic protection and design life of cathodic protection installations;
6) public and employee safety.

d) Test leads required for cathodic protection shall be maintained so that electrical measurements can be obtained to ensure adequate protection.

e) Cathodic protection rectifiers or other impressed current power source shall be inspected at intervals not exceeding 2 months.

f) All connected protective devices, including reverse current switches, diodes, and interference bonds, failure of which would jeopardize structure protection, shall be checked at intervals not exceeding 2 months. Other interference bonds shall be checked at least each calendar year but at intervals not exceeding 15 months.

g) Bare components in a piping system that are not protected by cathodic protection shall be electrically inspected at intervals not exceeding 5 years. The results of this inspection and leak records for the piping components inspected shall be analyzed to determine the location of localized active corrosion areas. Cathodic protection shall be applied at such areas. Inspections and analysis of leak and repair records shall be repeated at intervals not exceeding 5 years.

h) Buried or submerged piping components exposed for any reason shall be examined for indications of external corrosion. Discovery of active corrosion, general pitting of the component’s surface, or a leak caused by corrosion shall be investigated further to determine the cause and extent of the corrosion and whether cathodic protection shall be installed or augmented to mitigate corrosion or whether piping system or portion thereof shall be treated as indicated in section 12.3(b), (c), and (d).

12.3 INTERNAL CORROSION CONTROL
12.3.1 New Installations

a) Internal corrosion is recognized in the operation of liquid pipelines, and a commodity that will corrode the internal surfaces of pipe and components in a piping system shall not be transported unless the corrosive effect of the commodity has been investigated and adequate steps taken to mitigate internal corrosion. It is usually necessary to control internal corrosion. It is usually necessary to control internal corrosion in petroleum products and liquefied petroleum gas pipelines to protect product quality, preserve high line efficiencies, and prevent corrosive of internal surfaces. NACE RP-01-75 provides guidance. Frequent scraping, pigging, or sphering, dehydration, inhibition, or internal coating may be used to limit internal corrosion.

b) If dehydration or inhibitors are used to control internal corrosion, sufficient coupon holders or other types of monitoring techniques shall be utilized to adequately determine the effectiveness of the internal corrosion control program. Inhibitors shall be selected of a type that will not cause deterioration of any piping component and shall be used in sufficient quantity and proper quality necessary to mitigate internal corrosion.

c) If internal coatings are used to control corrosion, they shall meet the quality specifications and minimum dry film thickness established in the industry and be inspected in accordance with industry recommended practices. Internal coatings shall include provisions for joint protection on piping joined by welding or other methods exposing parent metal at the joints, such as the use of a suitable corrosion inhibitor.

12.3.2 Existing Piping Systems

The operating company shall establish procedures for determining the corrosive effect of the commodity being transported, and the internal condition of its existing piping systems, and take appropriate action for the conditions found, including, but not limited to, the following:

a) Examine and study records available from previous inspections.

b) Conduct additional inspections and investigations, such as intelligence pigging for internal corrosion and cross potential surveys for external corrosion, where the need for additional information is indicated. Corrective measures shall be in accordance with section 12.5.

12.3.3 Monitoring

a) If scraping, pigging, or sphering, dehydration, inhibitors, or internal coating are used to control internal corrosion in new or existing piping systems, coupons shall be examined or other monitoring techniques utilized at intervals not exceeding 6 months to determine the effectiveness of the protective measures or the extent of any corrosion. Appropriate corrective measures shall be taken where examinations or monitoring techniques indicate that adequate protection does not exist.

b) Wherever any pipe or component in a piping system can be visually examined internal, or pipe or component is removed from a piping system for any reason, the internal surfaces shall be inspected for evidence of corrosion, and if corrosion is found, the adjacent pipe or component shall be examined. Discovery of active corrosion, general pitting of the pipe or component surface, or a leak caused by corrosion shall be investigated further to determine the cause and extent of the corrosion and whether steps shall be taken or augmented to mitigate corrosion or whether system or portion thereof shall be treated as indicated in section 12.5(b), (c), and (d).

12.4 EXTERNAL CORROSION CONTROL FOR PIPING EXPOSED TO ATMOSPHERE

12.4.1 New Installations

Pipe and components that are exposed to the atmosphere shall be protected from external corrosion by use of corrosion resistant steel or application of protective coating or paint unless the operating company can demonstrate by test, investigation, or experience in area of application that a corrosive atmosphere does not exist. Protective
coating or paint shall be applied to a clean surface and shall be suitable material to provide adequate protection from the environment.

12.4.2 Existing Pipe Systems

Pipe and components in existing piping systems that are exposed to the atmosphere shall be inspected in accordance with a planned schedule and corrective measures shall be taken in accordance with section 12.5.

12.4.3 Monitoring

Protective coating or paint used to prevent corrosion of pipe and components exposed to the atmosphere shall be maintained in a serviceable condition, and such protective coating or paint, as well as bare pipe and components not coated or painted as permitted under section 12.4.1 shall be inspected at intervals not exceeding 3 years. Appropriate corrective measures shall be taken in accordance with section 12.5 where inspections indicate that adequate protection does not exist.

12.5 CORRECTIVE MEASURES

a) Criteria on corrosion limits and disposition of corroded pipe are specified in section 11.2.6.2 (a) (b) and 11.2.6.2(a) (7).

b) Where inspections or leakage history indicate that active corrosion of metal is taking place in any portion of a piping system to the extent that a safety hazard is likely to result, that portion of the system shall be treated as specified in section 11.2.6.2(a) (6) or (7) and:

1) in the case of external corrosion of buried or submerged piping, cathodic protection shall be installed or augmented to mitigate the external corrosion;

2) in the case of internal corrosion of piping steps indicated in section 12.3.1 shall be taken or augmented to mitigate the internal corrosion;

3) in the case of external corrosion of piping exposed to the atmosphere, protective coating or paint shall be repaired or applied to mitigate the external corrosion.

c) Pipe that is replaced because of external corrosion shall be replaced with coated pipe if buried or submerged, and with corrosion resistant steel pipe or coated or painted pipe if exposed to the atmosphere.

d) If a portion of the piping system is repaired, reconditioned, or replaced, or operating pressure is reduced because of external or internal corrosion, the need for protection of that portion from such corrosion deterioration shall be considered, and any indicated steps taken to control the corrosion.

12.6 RECORDS

a) Records and maps showing the location of cathodically protected piping, cathodic protection facilities, and neighbouring structures affected by or affecting the cathodic protection system shall be maintained and retained for as long as the piping system remains in service.

b) Results of tests, surveys, and inspections required by this Chapter to indicate the adequacy of corrosion control measures shall also be maintained for the service life of the piping system, as well as records relating to routine or unusual inspections such as internal or external line conditions when cutting line or hot tapping.