USA STANDARD

CODE FOR PRESSURE PIPING

Fuel Gas Piping

USAS B31.2 - 1968

Sponsor

The American Society of Mechanical Engineers

Published by

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

United Engineering Center 345 East 47th Street New York, N. Y. 10017

U S A S T A N D A R D

C O D E F O R P R E S S U R E P I P I N G

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AMERICAN NATIONAL STANDARD

This standard is one of more than 4000 approved as either a USA Standard or as an American Standard. It became an American National Standard in October 1969 when the Institute changed its name to American National Standards Institute, Inc.

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Foreword

THE need for a national code for pressure piping became increasingly evident from 1915 to 1925. To meet this need, the American Engineering Standards Committee (later changed to American Standards Association and then to United States of America Standards Institute) initiated Project B31 in March, 1926, at the request of the American Society of Mechanical Engineers and with that Society as the sole administrative sponsor. Because of the wide field involved, Standards Committee B31 was composed of representatives of some 40 different engineering societies, industries, government bureaus, institutes, and trade associations. After several years work, the first edition was published in 1935 as an American Tentative Standard Code for Pressure Piping.

In order to keep the code abreast of current developments in piping design, welding, stress computations, new dimensional and material standards and specifications and increases in the severity of service conditions, revisions, supplements and new editions of the code have been published as follows:

B31.1 – 1942 American Standard Code for Pressure Piping
1942 Procedure established for handling interpretation of code requirements
B31.1a – 1944 Supplement 1
B31.1b – 1947 Supplement 2
B31.1 – 1951 American Standard Code for Pressure Piping
B31.1a – 1953 Supplement 1 to B31.1 – 1951
B31.1 – 1955 American Standard Code for Pressure Piping

After a review by B31 Executive and Standards Committees in 1955, a decision was made to develop and publish industry sections as separate code documents of the USA Standard B31 Code for Pressure Piping. Section 2 of B31.1-1955 was revised extensively (in title, scope, format and contents) and approved by USASI on December 12, 1968 as USAS B31.2-1968, Fuel Gas Piping.

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USA STANDARD CODE FOR PRESSURE PIPING

Introduction

The Code for Pressure Piping (USAS B31) consists of a number of Sections, which collectively constitute the Code. Hereinafter in this Introduction and in the text of this Code Section B31.2, when the word "Code" is used without identification to another specific Code Section, it means this Code Section.

The Code for Pressure Piping sets forth engineering requirements deemed necessary for safe design and construction of piping systems. While safety is the basic consideration of this Code, this factor alone will not necessarily govern the final specifications for any pressure piping system. 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 Code contains basic reference data and formulas necessary for design. It is intended to state these requirements in terms of basic design principles to the fullest possible extent supplemented with specific requirements where necessary to obtain uniform interpretation of principle. It contains prohibitions in areas where practices or designs are known to be unsafe. In other areas the Code contains warnings or "flags" where caution is known to be necessary, but where it is felt that a direct prohibition would be unwise.

The Code includes:

(1) material specifications and component standards which have been accepted for Code usage.

(2) the designation of proper dimensional standards for the elements comprising piping systems.

(3) requirements for the design of component parts and assembled units, including necessary pipe supporting elements.

(4) requirements for the evaluation and limitation of stresses, reactions, and movements associated with pressure, temperature, and external forces.

(5) requirements for the fabrication, assembly, and erection of piping systems.

(6) requirements for testing and inspecting of elements before assembly or erection and of the completed systems after erection.

The components of piping systems should, as far as practicable, comply with the specifications and standards listed in the Code. Compliance with this Code requires that fundamental principles be followed and that materials or practices not specifically approved under this Code, but which are not prohibited by the Code, be qualified for use as set forth in the applicable chapters of the Code.

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.

This Code shall not be retroactive, or construed as applying to piping systems erected before, or under construction at the time of its approval by the United States of America Standards Institute.

Attention of users of the Code is directed to the fact that the numbering of the Divisions and the material thereunder may not be consecutive. Such discontinuity is recognized. It is not the result of editorial or printing errors. An attempt has been made, insofar as possible, to follow a uniform outline in the various Sections. Due to the fact that the complete outline may cover phases not applicable to a particular Section, the Code has been prepared with gaps in the numbering. It is believed that in this way, cross referencing between Sections is made easier and use of the Code is facilitated since the same subject, in general, appears under the same number and sub-number in all Sections.

The Code is under the direction of USA Standards Committee B31 of the United States of America Standards Institute and is under the administrative sponsorship of The American Society of Mechanical Engineers.

The Committee is a continuing one and is organized to keep the Code up to date in context and in step with the developments in materials, constructions and usage. Revisions are issued periodically. New editions are published at three to four year intervals depending on conditions.

USA Standards Committee B31 has established an orderly procedure to consider requests for interpretations and revisions of Code requirements. In order to receive consideration, inquiries shall be in writing and must give full particulars.

When an approved reply to an inquiry involves a change in Code requirements, the ruling is made public through the issuance of a "Case." This is published in Mechanical Engineering. A "Case Interpretation and Revision" service is maintained for the benefit of all who use the Code. Suggestions for revisions may originate within the Committee itself or from anyone outside the committee.

All requests for interpretations or suggestions for revisions should be addressed to the Secretary, USA Standards Committee B31, in care of The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017.

CHAPTER I

SCOPE AND DEFINITIONS

200 GENERAL

This Fuel Gas Piping Code is a Section of the USA Standard Code for Pressure Piping. This Section is published as a separate document for convenience.

The users of this Code are advised that in some localities legislation may establish governmental jurisdiction over the subject matter covered by the Code.

The selection of materials and components for the service and environment is part of the engineering design.

Standards and specifications approved for use under this Code and the names and addresses of the sponsoring organizations are shown in Appendix A. It is not considered practical to refer to a specific edition of each of the standards and specifications in the individual paragraphs. Instead, the specific edition references are included in Appendix A which will be revised at short intervals as needed.

It is required that the engineering design specify any special requirements pertinent to the particular service involved. For example, the engineering design shall not for any service specify a weld quality lower than that stipulated in Sub-paragraph 227.4.2 (d) and 227.4.3 (c) for the Code-required visual examination quality and for the types of welds involved; but where service requirements necessitates added quality and more extensive non-destructive examination, these are to be specified in the engineering design and any revision thereto, and when so specified, the Code requires that they be accomplished.

Some standards and specifications cited in Appendix A are supplemented by specific requirements elsewhere in this Code. Users of this Code are advised against attempting direct application of any of these standards without carefully observing the Codes reference to that standard.

This Code is written in terms of relatively simple requirements which are adequate for the conditions normally encountered in fuel gas piping installations. Detailed coverage is not given to all problems such as long self-supported spans, unstable ground, mechanical or sonic vibrations, weight of special attachments, and thermal forces other than seasonal. Where the Code provisions are inadequate to provide for such abnormal or unusual conditions, or where the Code user is specifically directed to do so, the piping system shall meet the design requirements of USAS B31.3 even if the system in question appears to be outside the scope of USAS B31.3

Before applying the requirements of any specific section of USAS B31.3, the designer should familiarize himself with the contents of that entire Code. In some cases, specific requirements in one section of USAS B31.3 may be materially modified or supplemented in another section of that Code to provide for changes in environmental conditions.

200.1 Scope

200.1.1 This Code covers the design, fabrication, installation, and testing of piping systems for fuel gases such as natural gas, manufactured gas, liquefied petroleum gas (LPG)-air mixtures above the upper combustible limit, liquefied petroleum gas (LPG) in the gaseous phase, or mixtures of these gases.

Included within the scope of this Code are fuel gas piping systems both in buildings and between buildings, from the outlet of the consumer's meter set assembly (or point of delivery) to and including the first pressure containing valve upstream of the gas utilization device. (See Figure B-1 in Appendix B).

200.1.2 Piping systems within the scope of this Code include all components such as pipe, valves, fittings, flanges (except inlet and outlet flanges that are a part of equipment or apparatus described in Par. 200.1.4), bolting and gaskets. Also included are the pressure containing parts of other components such as expansion joints, strainers and metering devices and piping supporting fixtures and structural attachments.

200.1.3 Piping systems covered by this Code may be used only at pressures permitted by the various limitations contained in this Code.

Vacuum piping systems are not covered by this Code. See Subdivision 222.5.

200.1.4 This Code does *not* apply to:

(a) Fuel gas piping systems with metal temperature above 450°F or below −20°F.

(b) Fuel gas piping systems in petroleum refineries, loading terminals, natural gas processing plants, bulk plants, compounding plants, or refinery tank farms, etc. within the scope of USAS B31.3.

(c) Fuel gas piping in power and atomic energy plants, within the scope of USAS B31.1.

(d) Gas gathering, transmission, and distribution piping systems (including compressor stations, metering stations, pressure regulating stations, etc.) for natural, manufactured, or diluted liquefied petroleum gases within the scope of USAS B31.8.

(e) Fuel gas piping systems within the scope of USAS Z21.30. (For the convenience of the Code user, the scope of USAS Z21.30-1964 is included in Appendix C.)

(f) Piping systems for conveying liquefied petroleum gas (LPG) in the liquid phase nor to containers or storage system for liquefied petroleum gases within the scope of USAS Z106.1.

(g) Proprietary items of equipment, apparatus, or instruments, such as compressors, gas generating sets and calorimeters.

(h) Design and fabrication of pressure vessels covered by the ASME Boiler and Pressure Vessel Code.

(i) Support structures and equipment such as stanchions, towers, building frames, pressure vessels, mechanical equipment, and foundations.

(j) Piping systems for conveying premixed fuel gas-air mixtures which are in the combustible or inflamable limits or range.

200.2 Definitions

Ambient Temperature. The temperature of the surrounding medium, usually used to refer to the temperature of the air in which a structure is situated or a device operates.

Atmospheric Pressure. The pressure of the weight of air and water vapor on the surface of the earth. Approximately 14.7 pounds per square inch (psi) at sea level.

Automatic Shut-off Device. Equipment which under abnormal conditions (either an increase or decrease in pressure from some predetermined value) will act to completely shut off the supply of gas flowing into a system. If the device is set to shut off at a decrease in pressure in the system being protected, the operation of this type of equipment may result in the reduction of pressure to 0 psig in that system.

Back-Pressure. Pressure against which a fluid is flowing, resulting from friction in lines, restrictions in pipes, valves, pressure in vessel to which fluid is flowing, hydrostatic head, or other impedient that causes resistance to fluid flow.

Brazing. A metal joining process wherein coalescence is produced by use of a non-ferrous filler metal having a melting point above 800 F, but lower than that of the base metals being joined. The filler metal is distributed between the closely fitted surfaces of the joint by capillary attraction.

Carbon Steel. By common custom steel is considered to be carbon steel when no minimum content is specified or required for aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium or zirconium, or any other element added to obtain a desired alloying effect; when the specified minimum for copper does not exceed 0.40 per cent; or when the maximum content specified for any of the following elements does not exceed the percentages noted: manganese 1.65, silicon 0.60, copper 0.60.

Clearing. The act of rapidly replacing the atmosphere by direct displacement so as to cause a minimum of mixing between the two atmospheres.

Control Piping. All piping, valves, and fittings used to interconnect air, gas, or hydraulically operated control apparatus or instrument transmitters and receivers.

Design Pressure. The maximum operating pressure permitted by this Code, as determined by the design procedures applicable to the materials involved.

Differential Pressure. The pressure difference between two points in a system.

Easement. A formal permission granted by landowners for laying and maintaining a gas pipe line.

Gas Main or Distribution Main. A pipe installed in a community to convey gas to individual services or other mains.

Header. A pipe or fitting to which a number of branch pipes are connected.

Hoop Stress. The stress in a pipe wall, acting circumferentially in a plane perpendicular to the longitudinal axis of the pipe and produced by the pressure of the fluid in the pipe.

Hot Taps. Branch piping connections made to piping systems while they are in operation.

Instrument Piping. All piping, valves, and

fittings used to connect instruments to main piping, to other instruments and apparatus, or to measuring equipment. The valve nearest the main piping shall not be considered instrument piping.

Joint. A connection between two lengths of pipe or between a length of pipe and a fitting.

Leakage Surveys. Systematic surveys made for the purpose of locating leaks in a gas piping system.

Maximum Allowable Hoop Stress. The maximum hoop stress permitted by this Code for the design of a piping system.

Maximum Working Pressure. The maximum pressure at which a piping system may be operated in accordance with the provisions of this Code. It is the pressure used in determining the setting of pressure relieving or pressure limiting devices installed to protect the system from accidental over-pressuring.

Monitoring Regulator. A pressure regulator set in series with another pressure regulator for the purpose of automatically taking over in an emergency the control of the pressure downstream of the regulator in case that pressure tends to exceed a set maximum.

Operating Stress. The stress in a pipe or structural member under normal operating conditions.

Pressure. Unless otherwise stated is expressed in pounds per square inch above atmospheric pressure, i.e., gage pressure (psig).

Pressure Control. Manual or automatic maintenance of pressure, in all or part of a system, at a predetermined level, or within a selected range.

Pressure Limiting Device. Equipment which under abnormal conditions will act to reduce, restrict or shut off the supply of gas flowing into a system in order to prevent the gas pressure in that system from exceeding a predetermined value.

Pressure Regulator. Equipment which automatically controls the pressure in a fluid flow line.

Purging. The act of replacing air within a gas fuel line with gas in such a manner as to prevent the formation of an explosive mixture or replacing gas with air to prevent the formation of an explosive mixture.

Relief Valve. Equipment installed to vent gas from a system being protected in order to prevent the gas pressure from exceeding a predetermined limit.

Seal Weld. A weld made around threaded joints to eliminate possible leakage. One pass with a welding electrode or rod is usually sufficient for this purpose.

Secondary Stress. Stress created in the pipe wall by loads other than internal fluid pressure. For example, backfill loads, traffic loads, beam action in a span, loads at supports and at connections to the pipe.

Series Regulator. A pressure regulator in series with one or more other pressure regulators. The regulator nearest to the gas supply source is set to continuously limit the pressure on the inlet to the regulator downstream to some predetermined value (between the pressure of the gas supply source and the pressure of the system being controlled) which can be tolerated in the downstream system.

Service Regulator. A regulator installed on a gas service line to control the pressure of the gas delivered to the customer.

Specified Minimum Elongation. The minimum elongation (expressed in percent of the gage length) in the tensile test specimen, prescribed by the specifications under which the material is purchased from the manufacturer.

Specified Minimum Tensile Strength. The minimum tensile strength prescribed by the specification under which pipe is purchased from the manufacturer (psi).

Specified Minimum Yield Strength. The minimum yield strength prescribed by the specification under which pipe is purchased from the manufacturer (psi).

Stress. The resultant internal force that resists change in the size or shape of a body acted on by external forces. In this code "stress" is often used as being synonymous with unit stress which is the stress per unit area (psi).

Tensile Strength. The highest unit tensile stress (referred to the original cross-section) a material can sustain before failure (psi).

Welding Nomenclature. Types of welds and names of welded joints are used herein according to their common usage as defined in the American Welding Society publication "Standard Welding Terms and Their Definitions" (AWS A3.0), or as specifically defined as follows:

A. *Electric-Resistance-Welded Pipe.* Pipe produced in individual lengths, or in continuous lengths from coiled skelp and subsequently cut into individual lengths, having a longitudinal 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.

Typical specifications: ASTM A 53, ASTM A 135, API 5L, API 5LX.

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.

Typical specifications: ASTM A 53, API 5L.

C. *Furnace Butt-Welded Pipe.*

(1) Bell-Welded. Furnace-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 a "welding bell") which serves as a combined forming and welding die.

Typical specifications: ASTM A 53, API 5L.

(2) Continuous-Welded. Furnace-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.

Typical specifications: ASTM A 53, API 5L.

D. *Electric-Fusion-Welded Pipe.* Pipe having a longitudinal 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.

Typical specifications:

ASTMA A 134 and ASTM A 139 – Single or double weld is permitted with or without the use of filler metal.

ASTM A 155 – Requires both inside and outside welds and the use of filler metal.

Spiral-welded pipe is also made by the electric-fusion-welded process with either a butt joint, a lap joint or a lock-seam joint.

Typical specifications:

ASTM A 134 and ASTM A 139 – Butt joint.

ASTM A 211 – All Joints.

E. *Electric-Flash-Welded Pipe.* Pipe having a longitudinal butt joint wherein coalescence is produced, simultaneously over the entire area of abutting surfaces, 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.

Typical specifications: API 5L, API 5LX.

F. *Double Submerged-Arc-Welded Pipe.* Pipe having a longitudinal 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.

Typical specifications: ASTM A 381, API 5LX.

Zero Governor. A regulating device which is normally adjusted to deliver gas at atmospheric pressure within its flow rating.

CHAPTER II

DESIGN

PART 1: CONDITIONS AND CRITERIA

201 DESIGN CONDITIONS

201.1 General

Piping systems installed in open easements, which are accessible to the general public or to individuals other than the owner of the piping system or his employee or agent shall be designed in accordance with USAS B31.8.

201.2 Pressure

201.2.1 *Maximum Working Pressure Limits In Buildings*

(a) When not specifically required by a gas using process or equipment, the maximum working pressure for piping systems installed in buildings intended for human use and occupancy shall not exceed 10 psig. (See Subdivision 222.2 for requirements applicable to pressure controlling devices.)

(b) The above limitation on maximum working pressure does not apply to piping installed in buildings or portions of buildings devoted exclusively to the metering, regulating, compressing, or conditioning of gas. If a portion of a building is used for metering, regulating, etc., there shall be no openings (which will permit the interchange of atmospheres) between that portion of the building devoted to such uses and the remainder of the building.

201.2.2 *Design Pressure*

(a) The piping system shall be designed for a pressure representing the most severe condition of coincident pressure and temperature expected during normal operation. The most severe condition of coincident pressure and temperature shall be that condition which results in the greatest required pipe thickness and the highest flange rating.

(b) Every piping system, regardless of anticipated service conditions shall have a design pressure of at least 10 psig between the temperatures of minus 20 F and 250 F.

201.3 Temperature

201.3.2 *Design Temperature*

The design temperature is the ambient or gas temperature representing the most severe condition of coincident pressure and temperature as explained in Paragraph 201.2.1.

201.5 Dynamic Effects

201.5.2 *Wind*

Under normal or usual operating conditions, effects due to wind, need not be considered. In exposed locations where wind loading may be of importance, formal calculations shall be made to determine stresses and reactions.

201.5.3 *Earthquake*

Piping systems located in regions where earthquakes are a factor, shall be designed for a horizontal force in conformity with good engineering practice, using governmental data as a guide in determining the earthquake force. This force, however, is not to be considered as acting concurrently with lateral wind force.

201.5.4 *Vibration*

Piping shall be arranged and supported with consideration to vibration. Sway braces or vibration dampeners may be used to limit the movement of piping due to vibration.

201.6 Weight Effects

The following weight effects combined with loads and forces from other causes shall be taken into account in the design of piping.

201.6.1 *Live Loads*

The live load consists of snow and ice loads where such conditions exist.

201.6.2 *Dead Loads*

Dead loads consist of the weight of the piping components and other superimposed permanent loads.

201.6.3 *Test Loads*

The test load consists of the weight of the test fluid.

201.7 Thermal Expansion and Contraction Loads

Piping systems shall be designed to have sufficient flexibility to prevent thermal expansion or contraction from causing excessive stresses in the piping material, excessive bending or unusual loads at joints, or undesirable forces or moments at points of connections to equipment or at anchorage or guide points. See Division 219.

201.8 Thrust Forces

The forces transmitted to connected equipment shall be kept within safe limits.

Bends or offsets in buried pipe cause longitudinal forces, which must be resisted by anchorage at the bend, by restraint due to friction of the soil, or by longitudinal stresses in the pipe. Where there is doubt as to the adequacy of anchorage by soil, friction calculations should be made.

202 DESIGN CRITERIA

202.1 General

Division 202 pertains to ratings, stress values, stress criteria, design allowances, and minimum design values, and formulates the permissible variations to these factors used in the design of piping.

202.2 Pressure-Temperature Ratings for Piping Components

202.2.1 *Method of Establishing and Applying Pressure-Temperature Ratings*

(a) For components having established pressure-temperature ratings, the pressure rating of the components at the design temperature shall equal or exceed the design pressure of the piping system. Where necessary the pressure-temperature ratings may be interpolated.

(b) For components having an established pressure rating, but the temperature at which the pressure rating was established is unknown or unascertainable, that temperature shall be assumed to be 100 F.

(c) For components having only one pressure rating established at a temperature other than 100 F, but within the range of minus 20 F and 150 F, that pressure rating shall be assumed to apply at any temperature within that range.

(d) For components having no established pressure-temperature rating (such as pipe and butt welding fittings), the provisions of Divisions 203 and 204 shall apply.

202.2.2 *Connections Between Systems and to Equipment*

When two lines that operate at different pressure-temperature conditions are connected, the valve separating 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 more severe pressure-temperature condition than that of the line, the valve separating the line from the equipment shall be rated for at least the maximum rated operating conditions of the equipment.

202.3 Allowable Stresses and Other Stress Limits

202.3.1 *Allowable Stress Values*

For piping components having no established pressure-temperature rating (See Par. 202.2.1) and for which the design pressure must be determined by the use of the formulas listed or referred to in Division 204:

(a) The basic allowable stress values shall be those determined from Table 202.3.1. (See Appendix D). For materials not listed in Table 202.3.1, the basic allowable stress values shall be those listed in USAS B31.3. The basis for establishing basic allowable stress values is that described in USAS B31.3.

(b) The allowable stress values in the shear shall be 0.80 of the basic allowable stress values.

(c) The allowable stress values in bearing shall be 1.60 of the basic allowable stress values.

202.3.2 *Stress Limits*

(a) The sum of the longitudinal stresses produced by pressure, live and dead loads shall not exceed the allowable stress values given in this code. The sum of longitudinal stresses produced by pressure, live and dead loads, and those produced by occasional loads such as wind or earthquake shall not exceed 1.33 times the allowable stress values given in this Code. It is not necessary to consider wind and earthquake as ocurring concurrently.

(b) Stresses due to test conditions are not subject to the limitations of this Subdivision. It is not necessary to consider other occasional loads, such as wind and earthquake as occurring concurrently with the loads existing at the time of the test.

202.4 Allowances

202.4.1 *Corrosion Allowances for Steel Pipe*

The design requirements contained herein for steel piping systems are applicable without modification only: (1) when the gas conveyed is substantially non-corrosive and the piping system is installed in a substantially non-corrosive environment, or (2) in the event the piping system is installed in a corrosive environment, suitable steps are taken to mitigate external corrosion.

If a corrosive gas is to be conveyed or if suitable means of preventing external corrosion are not provided, the thickness of the pipe wall

shall be increased to provide an allowance for corrosion. The minimum corrosion allowances to be provided in such cases shall not be less than 0.05 inches for external corrosion nor less than 0.075 inches for internal corrosion.

If both external and internal corrosion are anticipated, the corrosion allowance shall be at least 0.125 inches. The allowances indicated above shall be added to the wall thickness as computed by the formula in Subdivision 204.1. In no case, however, shall the wall thickness of steel pipe be less than that stipulated in Subdivision 204.1.

For the purposes of this Section of the Code, a corrosive gas shall be one in which the water dew-point may at anytime exceed the temperature of the piping. Some gases may be substantially non-corrosive even though their water dew-point exceeds piping temperatures. Such gases, however, shall be assumed to be non-corrosive only if proven so by careful tests or experience. Conversely, some gases may be corrosive even though their water dew-point never exceeds piping temperature. If experience indicates this to be the case, an internal corrosion allowance not less than 0.075 inches shall be applied.

202.4.2 *Threading*

No allowance need be made for threads or grooves in pipe provided that the least nominal wall thickness requirements specified in Table 204.1 are met, and provided that the thread depth or groove depth does not exceed dimension h in USAS B2.1. For threads or grooves having depths greater than those indicated above, the wall thickness of the pipe shall be increased accordingly.

202.4.3 *Weld Joint Factors*

Where this Code requires the use of longitudinal weld joint factor, those established in Table 202.4.3 shall be used.

Table 202.4.3
Longitudinal Weld Joint Factor "E"

Type of Joint	E
1. Arc or Gas Weld	
a. Double Welded Butt	0.85
b. Double Welded Butt, with joints in accordance with Note 1.	0.90
c. Double Welded Butt, with 100% radiography in accordance with Par. UW-51 (a through k) of Section VIII of the ASME Boiler and Pressure Vessel Code, and conforming with the requirements of Par. 227.43 of this Code.	1.00
d. Single Welded Butt	0.80
e. Single Welded Butt, with joints in accordance with Note 1.	0.90
f. Single Welded Butt, with 100 per cent radiography in accordance with Par. UW-51 (a through k) of Section VIII of the ASME Boiler and Pressure Vessel Code, and conforming with the requirements of Par. 227.4.3 of this Code.	1.00
g. Spiral Welded	0.75
2. Electric Resistance Weld and Electric Flash Weld	0.85
3. Furnace Weld	
a. Lap Weld	0.75
b. Butt Weld	0.60

Note 1. Welds with 0.90 joint factor shall be finished, random radiographed by the technique, and evaluated in accordance with UW-51 of Section VIII of the ASME Boiler and Pressure Vessel Code. Radiographing (random) shall consist of not less than 12 inches of radiography per 100 feet of weld with re-examination and repair in accordance with UW-52 of Section VIII of the ASME Boiler and Pressure Vessel Code.

202.4.4 *Mechanical Strength*

When necessary to prevent damage, collapse, or buckling due to superimposed loads from supports, backfill or other causes, the pipe wall thickness shall be increased or, if this is impractical or would cause excessive local stresses, the factors that would contribute to damage of the piping shall be corrected by other acceptable design methods. Piping shall be placed, protected and/or supported so that it is protected against damage due to impact from moving objects.

PART 2: PRESSURE DESIGN OF PIPING COMPONENTS

203 DESIGN CRITERIA

The formulas given in Subdivision 204.1 are intended for use with thin wall pipe. For the purpose of this Section of the Code, thin wall pipe shall be any pipe where the minimum wall thickness does not exceed 0.10 of the nominal diameter. Where the minimum wall thickness as calculated in Subdivision 204.1 is in excess of 0.10 of the nominal diameter, the piping system shall meet the requirements of USAS B31.3.

204 DESIGN OF COMPONENTS

204.1 Pipe

The minimum required thickness of metallic pipe or tubing shall be equal to or greater than the design thickness (t) as calculated by the formula given below, except that (a) corrosion, threading, and other allowances shall be added to the calculated design thickness if required under Subdivision 202.4 and (b) the nominal wall thickness shall not be less than the wall thickness requirements specified in Table 204.1. The wall

thickness listed in Table 204.1 are deemed adequate for internal pressures of 10 psig or less.

$$t = \frac{PD}{2SE}$$

Where: t = design thickness of pipe or tubing, inches
P = internal design pressure, psig
D = outside diameter of pipe or tubing, inches
S = allowable stress, psi (see Par. 202.3.1)
E = longitudinal joint efficiency factor (see Par. 202.4.3)

$$t \leq t_n - t_t - h - c$$

where t_n = nominal wall thickness, inches
t_t = minus tolerance on wall thickness, inches. (See applicable pipe specification. If specification is unknown, use $t_t = 0.125 \times t_n$)
h = allowance for threads, grooves, etc. as required, inches (See Para. 202.4.2)
c = allowance for corrosion as required, inches. (See Para. 202.4.1)

(Note: The internal design pressure for metallic pipe or tubing shall be determined by the following transposition of the above formula:

$$P = \frac{2SEt}{D}$$

Table 204.1

Least Nominal Wall Thickness For Pipe and Tubing

Nominal Diameter (Inches)	Steel Pipe or Tubing		Copper or Aluminum Pipe or Tubing		Nodular Iron (Ductile) Centrifugally Cast Pipe
	Threaded or Grooved	Plain End	Threaded or Grooved	Plain End	
1/8	0.068	0.032	0.062	0.025	
3/16		0.032		0.028	
1/4	0.088	0.035	0.083	0.030	
5/16		0.035		0.035	
3/8	0.091	0.035	0.090	0.035	
1/2	0.109	0.035	0.107	0.035	
5/8		0.035		0.042	
3/4	0.113	0.049	0.114	0.045	
7/8		0.049		0.049	
1	0.133	0.049	0.126	0.049	
1-1/4	0.140	0.065	0.146	0.055	
1-1/2	0.145	0.065	0.150	0.060	
2	0.154	0.065	0.156	0.070	
2-1/2	0.203	0.083	0.187	0.080	
3	0.216	0.083	0.219	0.090	0.31
4	0.237	0.083	0.250	0.110	0.32
5	0.258	0.109	0.250	0.125	
6	0.280	0.109	0.250	0.140	0.34
8	0.277	0.109	0.312	0.188	0.36
10	0.279	0.134	0.365	0.188	0.38
12	0.330	0.156	0.375	0.188	0.40
14		0.210			
16		0.219			
18 and larger		0.250			

(Note: Metallic pipe or tubing having nominal wall thicknesses equal to or greater than those listed in the above Table shall be deemed adequate for internal design pressures of 10 psig or less. It is not necessary to make computations when pipe or tubing having the above wall thickness is used in piping systems having design pressures of 10 psig or less.)

204.2 Pipe Bends

204.2.1 *Wall Thickness*

The minimum wall thickness of mitered, wrinkled, or smooth pipe bends shall be determined as for straight pipe.

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

The minimum pipe wall thickness after bending shall not be less than that required for straight pipe under Subdivision 204.1. For smooth bends, the bending operation shall not produce a difference between the maximum and minimum diameters greater than 8 per cent of the nominal outside diameter of the pipe. Greater flattening may be permitted or less flattening may be required by the design, depending on the service conditions, the material, the stress levels involved, and the method of making the bend. Bends made with greater flattening shall meet the requirements of Subdivision 204.7.

204.2.2 *Non-Standard Bends or Elbows*

Commercially made bends or elbows not manufactured in accordance with the standards listed in Table 226.1 shall meet the requirements of Subdivision 204.7 and 226.2.

204.3 Branch Connections

Field fabricated branch connections or factory-made threaded or welding tee fittings or extruded headers may be used provided that all of the applicable requirements listed in the paragraphs below are met.

204.3.1 *Wall Thickness*

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

The nominal thickness of steel butt welding tees manufactured in accordance with the standards listed in Table 226.1 shall be not less than the minimum thickness required for the adjoining pipe if of the same grade.

204.3.2 *Non-Standard Tees*

Commercially made tee fittings not manufactured in accordance with the standards listed in Table 226.1 shall meet the requirements of Subdivision 204.7 and 226.2.

204.3.3 *Tapped Connections In Steel Systems*

The pressure rating of a tapped branch connection in a steel piping system shall be the same as that of the header pipe if the following conditions are met:

(a) The header pipe has at least the nominal wall thickness as given for threaded pipe in Table 204.1.

(b) The branch connection is being made for the purpose of connecting instruments or gages to the main piping or for connecting burner pipes to a manifold.

(c) The branch connection is located in an exposed location that will permit inspection.

(d) The branch connection is seal welded if it is subjected to a design pressure above 50 psig.

(e) The nominal size of the branch pipe does not exceed 25 per cent of the nominal size of the header pipe or 2 inches, which ever is the lesser of the two.

(f) The connection shall be tapped so that there is a thread engagement of not less than 3½ American Standard Pipe Threads.

Tapped connections which fail to meet any of the above conditions are prohibited.

204.3.4 *Tapped Connections in Nodular Iron Systems*

The pressure rating of a tapped branch connection in a nodular (ductile) iron piping system shall be the same as that of the header pipe if the size of the threaded tap is not more than 25 per cent of the nominal diameter of the pipe, except that 1¼ inch taps are permitted in 4 inch pipe. This same method of determining pressure rating shall apply to larger taps if they are covered by a reinforcing sleeve. Reinforcing sleeves, if used, shall be designed to limit stresses in the branch and header pipe to the allowable values given in this Code and shall provide proper thread engagement.

204.3.5 *Tapped Connections in Non-Ferrous Systems*

Tapped connections in non-ferrous systems are prohibited.

204.3.6 *Welded Connections*

(a) The design of welded branch connections shall take into consideration 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 any branch openings, and any external loadings due to thermal movement, weight, vibration, etc. When external loadings are not present, and when the branch connections are attached at an angle of 85–90 degrees; a header pipe thickness at least twice the minimum required thickness, including all allowances, required in Subdivision 204.1 shall be deemed adequate reinforcement. The increased header thickness shall extend for at least five branch pipe diameters on each side of the centerline of the intersection. In such event, no stress calculations are required. Where the above condi-

tions do not exist, the rules governing the design of branch connections, as set forth in Subdivision 304.3 of ASA B31.3, are applicable. (See Par. 227.4.6.)

(b) When two adjacent field welded branches are spaced so that the distance between their center lines is more than twice their average nominal diameter, each branch may be considered as a single opening and the provision of the preceding paragraph may be applied without modification.

(c) When two adjacent welded branches are spaced so that the distance between their center lines is less than twice their average nominal diameter; the reinforcement shall be calculated in the manner specified in Subdivision 304.3 of ASA B31.3.

204.3.7 *Extruded and Reinforced Connections*

Extruded branch connections, or externally reinforced branch connections, shall be designed in accordance with the requirements of ASA B31.3.

204.4 Heads and Closures

Fabricated flat, ellipsoidal, spherical, and conical heads shall be designed in accordance with the requirements of Section VIII of the ASME Boiler and Pressure Vessel Code, using the allowable stress values specified in Table 202.3.1.

Flat closures larger than 3 inch diameter shall be designed according to Section VIII, Unfired Pressure Vessels, of the ASME Boiler and Pressure Vessel Code.

204.5 Flanges

204.5.1 *Standard Flanges*

Flanges manufactured in accordance with the Standards listed in Table 226.1 shall be considered suitable for use at the pressure-temperature ratings specified by such standards.

204.5.2 *Non-Standard Flanges*

Where conditions require the use of flanges other than those made to a Standard listed in Table 226.1, such flanges shall be designed in accordance with Subdivision 304.5 of ASA B31.3.

204.6 Reducers

Reducer fittings manufactured in accordance with the Standards listed in Table 226.1 shall be considered suitable for use at the pressure-temperature ratings specified by such Standards, and in the case of Standards under which reducer fittings are made to a nominal pipe thickness, the reducer fittings shall be considered suitable for use with pipe of the same nominal thickness.

204.7 Pressure Design of Other Pressure Containing Components

204.7.1 *Components Covered By Standards Listed In Code*

(a) All pressure containing components manufactured in accordance with the standards listed in Table 226.1 shall be considered suitable for use at pressure-temperature ratings specified by such Standards.

Components which are covered by standards listed in Table 226.1 but which do not conform to such standards shall not be used except as permitted in the following paragraph.

(b) Items of a type for which standards or specifications are listed in this Code but which do not conform to the standards, and are relatively unimportant from a safety standpoint because of their small size or because of the conditions under which they are to be used, may be used provided that:

(1) They are tested and investigated and found suitable for the proposed service,

(2) They are used at unit stresses not greater than 50 per cent of those allowed by this Code for comparable materials,

(3) Their use is not specifically prohibited by this Code.

204.7.2 *Components Not Covered By Standards Listed In Code*

(a) Pressure containing components of a proprietary nature (i.e., items of a type for which no Standards or Specifications are listed in this Code) may be qualified by the user by investigation and tests (if needed) that demonstrate that the component is suitable and safe for the proposed service, and provided further that the component is recommended for that service from the standpoint of safety by the manufacturer. This shall not be construed to permit the use of materials falling into the category given in Par. 223.1.3 except as permitted therein.

(b) Pressure containing components of a non-proprietary nature which are not covered by the standards listed in Table 226.1 and for which design formulas or procedures are not given in this Division, may be used where the design of similarly shaped, proportioned and sized components has been proved satisfactory by successful performance under comparable service conditions. (Interpolation may be made between similarly shaped proven 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:

(1) Proof tests (as are described in Par. UG-101 of Section VIII of the ASME Boiler and

Pressure Vessel Code) evaluated to include, where applicable, consideration for fatigue.

(2) Experimental stress analysis.

204.7.3 *Special Valves*

Special valves not specifically covered by standards listed in Table 226.1 may be used within the manufacturer's pressure-temperature recommendations provided a prototype valve has been subjected to performance tests to determine the safety of the valve under simulated service conditions. When vibration, fatigue, cyclic conditions, low temperature, etc., are anticipated, the applicable conditions shall be incorporated in the tests.

PART 3: SELECTION AND LIMITATIONS OF PIPING COMPONENTS

205 PIPE OR TUBING

205.1 General

Steel pipe or tubing conforming to the standards and specifications listed in Table 202.3.1 (Appendix D) may be used within the limitations of temperature and stress shown in Table 202.3.1 and within the additional limitations contained in this Code.

205.2 Metallic Pipe and Tubing

205.2.1 *Ferrous Pipe and Tubing*

(a) Nodular iron pipe three inch nominal size or larger may be used for underground service outside building foundation boundaries. Nodular iron pipe shall not be used underground within building foundation boundaries. Nodular iron pipe may be used above ground provided that the joints are properly restrained against movement and separation.

(b) Cast iron pipe shall not be used for any piping system within the scope of this Code.

205.2.2 *Non-Ferrous Pipe*

(a) Copper or brass pipe, or tubing, may be used within the limitation of temperature and stress shown in Table 202.3.1 (Appendix D) providing the following requirements are met:

(1) The gas carried does not contain more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet of gas. This is equivalent to a trace as determined by the lead acetate test. (Note: Tin-lined copper pipe or tubing may be used where the gas carried contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet of gas.)

(2) When installed within a building, the piping shall be suitably protected against external damage.

(b) Copper or brass tubing shall be joined by using either a flared type fitting or a brazed lap joint.

(c) Provision shall be made to prevent harmful galvanic action when copper or brass components are connected to steel components. This can be accomplished in most cases by using one of the following methods:

(1) Install an insulating type coupling, or an insulating flange, between the copper and steel, or

(2) Protect the copper and steel for a distance of two feet or more in all directions from the junction with insulating pipe corrosion protection material.

(d) Aluminum pipe or tubing conforming to the standards and specifications listed in the Table 202.3.1 may be used within the limitations of temperature and stress shown in Table 202.3.1 and within the additional limitations contained in this Code.

1) Aluminum pipe or tubing shall not be used where it is in contact with masonry or plaster.

2) In environments where an external protective oxide film does not reform readily, aluminum should be protected adequately or not used at all. Among such conditions are contact with strongly acid or alkaline solutions and contact with constantly moist corrosive materials that prevent free and uniform access of oxygen to the aluminum surface.

3) The highly anodic electrode potential of aluminum causes it to be dissolved sacrificially when in contact with most other metals in corrosive environments. This fact shall be taken into consideration in the design of any aluminum piping system within the scope of this Code.

205.3 Non-Metallic Pipe

Non-metallic pipe or tubing except as provided in 205.4 shall not be used in piping subject to pressure. Such piping may be used, however, in vent lines provided the material is compatible with the fuel gas being vented.

205.4 Non-Metallic Hose and Flexible Connectors

Neither non-metallic hose nor flexible connectors shall be used as part of the fuel gas piping system. Approved or listed flexible connectors or hose may be used, however, to connect appliances or equipment to building piping located in the same room provided that a valve is installed immediately ahead of the connector or

hose. There shall be no valve between the connector or hose and the point of utilization except that normally provided by the equipment manufacturer. No part of the connector or hose shall be concealed in walls, floors or ceilings.

The use of non-metallic hose shall be further limited to connect only laboratory, shop or ironing equipment which require mobility during operating.

206 FITTINGS AND BENDS

206.1 Fittings

Ferrous threaded fittings shall be malleable iron, cast steel or forged steel, or nodular iron, except that in sizes 4 inch and larger, cast iron fittings may be used when installed outside the walls of buildings.

Reducing couplings are preferred to bushings. Cast iron bushings shall not be used. When bushings are used, they shall reduce at least two pipe sizes.

Fittings in copper or brass piping systems and exposed to the soil should be made of bronze, copper or brass. Brass fittings exposed to the soil shall contain at least 80 per cent copper. If iron or steel fittings are used in copper or brass piping systems, they shall be protected from contact with the soil and/or insulated from the copper or brass pipe. (See Par. 205.2.2(c).)

206.2 Bends

Change of direction may be made by the use of smooth bends, elbows, or miters.

Mitered bends are permitted subject to the following limitations:

(a) Miters shall not be used in systems having a design pressure greater than 50 psig. Deflections caused by misalignments up to 3 degrees are not considered as miters.

(b) The total deflection angle at each miter shall not exceed 90 degrees.

(c) Care shall be taken in making mitered joints to provide proper root opening and alignment and full weld penetration.

Factory made welding elbows or transverse segments cut therefrom may be used for changes in direction provided that the arc length measured along the crotch is at least one inch in pipe sizes 2 inch. and larger.

206.8 Special Fittings and Connections

Orange-peel bull plugs and orange-peel swages and fish tails shall not be used.

207 VALVES

Valves complying with applicable standards and specifications listed in Table 226.1 shall be used within the limitations specified in this Code and shall be used in accordance with the service rating of the manufacturer.

Valves installed in copper or brass lines may be made of any suitable material permitted by this Code, except that ferrous valves installed in underground copper or brass piping shall be protected from contact with the soil and/or insulated from the copper or brass piping. (See Par. 205.2.2 (c).)

208 FLANGES, GASKETS, AND BOLTING

208.1 Flanges

208.1.1 *General*

Flanges complying with the applicable standards and specifications listed in Table 226.1 shall be used within the limitations specified in this Code. Reducing flanges which comply with the Standards listed in Table 226.1 may be used.

Standard blind flanges may be altered for use as threaded flanges or slip-on welding flanges. Standard reducing threaded flanges may be altered for use as slip-on welded flanges. Attention is directed to restrictions on use of threaded joints contained in Division 214.

Lapped flanges may be used only above ground or in exposed locations accessible for inspection.

208.1.2 *Non-Standard Flanges*

Forged steel welding neck flanges having an outside diameter and drilling the same as USAS B16.1, but with modified flange thicknesses, hub dimensions, and special facing details, may be used to bolt against flat faced cast iron flanges and operate at the pressure-temperature ratings given in USAS B16.1 provided:

(a) The minimum flange thickness T is not less than that shown in the table below.

(b) Flanges are used with non-metallic full face gaskets extending to the periphery of the flanges.

(c) The design has been proved by test to be suitable for the USAS B16.1 ratings.

Pipe Size Inches	Minimum Thickness of Flange Inches	Pipe Size Inches	Minimum Thickness of Flange Inches
6 & 8	9/16	22 to 30, Incl.	1
10 & 12	11/16	32 to 36, Incl.	1-1/8
14 to 20, Incl.	3/4		

208.2 Blind Flanges

Blind flanges manufactured in accordance with the standards listed in Table 226.1 may be used within the limitations of this Code. Blind flanges not manufactured in accordance with those standards may be used provided that they meet

the requirements of UG-34 of Section VIII of the ASME Boiler and Pressure Vessel Code. Blind flanges may be fabricated directly from plate materials with mechanical properties equal to or better than the permissible forged materials. Flanges on which welding may be required shall also be of weldable quality.

208.3 Flange Facings

Flange facings complying with Standards listed in Table 226.1 are suitable for use under this Code with the following exceptions:

(a) When 150 lb steel flanges are bolted to Class 125 cast iron flanges, the 1/16 inch raised face on the steel flange shall be removed. (See Subdivision 208.5 for bolting.)

(b) When 300 lb steel flanges are bolted to Class 250 cast iron flanges, it is recommended that the raised face on the steel flange be removed.

Cast iron and steel flanges shall have contact faces finished in accordance with MSS SP-6.

208.4 Gaskets

208.4.1 *General*

The materials used for gasketing shall conform to the requirements of Subdivision 225.3.

208.4.2 *Asbestos Composition Gaskets*

Asbestos composition gaskets may be used as permitted in USAS 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.

208.4.3 *Metallic Gaskets*

The use of metal or metal-jacketed asbestos gaskets (either plain or corrugated) is not limited 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.

208.4.4 *Gasket Dimensions*

Full-face gaskets shall be used with all bronze flanges, and should be used with Class 25 or Class 125 cast iron flanges. Flat ring gaskets with an outside diameter extending to the inside of the bolt holes may be used with: (a) cast iron flanges, (b) with raised face steel flanges, or (c) with lapped steel flanges.

In order to secure higher unit compression on the gasket, metallic gaskets (where permitted) of a width less than the full male face of the flange may be used with raised face, lapped or large male and female facings. Width of gasket for small male and female or for tongue and groove joints shall be equal to the width of the male face or tongue.

Rings for ring joints shall be of dimensions established in USAS B16.20. The material for these rings shall be suitable for the service conditions encountered and shall be softer than the flanges.

208.5 Flange Bolting

208.5.1 *General*

When steel flanges are bolted to cast iron flanges, the requirements applicable to cast iron flanges shall govern. (See Subdivision 208.3 and Paragraph 208.4.4.)

When steel flanges or cast iron flanges are bolted to brass or bronze flanges, the requirements applicable to brass or bronze flanges given in Par. 208.4.4 and 208.5.5 shall govern.

The term "bolting material," as used herein, means bolts, stud bolts and nuts, except where the context clearly indicates some other meaning.

208.5.2 *Machine Bolt and Nut Dimensions*

Bolt heads shall have the dimensions and tolerances specified for regular square heads or heavy hexagon heads in USAS B18.2.1.

Nuts shall have the dimensions and tolerances specified for heavy hexagon nuts in USAS B18.2.1.

208.5.4 *Bolting Material for Cast Iron Flanges*

(a) When full face gaskets are used with Class 25 and Class 125 cast iron flanges, the bolting material shall comply with the requirements of either ASTM A307, ASTM A325, ASTM A354, or ASTM A193. When 1/8 inch undersize bolting material is used for insulating flanges, the bolting material shall comply with the requirements of ASTM A354 or ASTM A193.

(b) When flat ring gaskets are used with Class 25 or Class 125 cast iron flanges, the bolting material shall comply with the requirements of ASTM A307, Grade B.

(c) Bolting material for Class 250 cast iron flanges shall comply with the requirements of ASTM A307, Grade B.

(d) Nuts cut from bar stock in such a manner that their axis will be parallel to the direction of rolling of the bar may be used with all sizes and classes of cast iron flanges.

208.5.5 *Bolting Material for Brass or Bronze Flanges*

Bolting material for 150 lb or 300 lb brass or bronze flanges shall comply with the requirements of ASTM A307, Grade B. The bolts and stud bolts shall have no heat treatment other than stress relief.

208.5.6 *Bolting Material for Steel Flanges*

(a) When the design pressure of the piping system is 300 psig or lower, the bolting material shall comply with the requirements of either ASTM A307, ASTM A325, ASTM A354, or ASTM A193. When 1/8 inch undersize bolting material is used for insulating flanges, the bolting material shall comply with the requirements of ASTM A354 or ASTM A193.

(b) When the design pressure of the piping system is more than 300 psig but the design temperature is 150 F or lower, the bolting material shall comply with the requirements of ASTM A325, A354, or A193.

(c) When the design pressure of the piping system is more than 300 psig and the design temperature is more than 150 F, the bolting material shall comply with the requirements of ASTM A354 or ASTM A193.

PART 4: SELECTION AND LIMITATIONS OF PIPING JOINTS

210 PIPING JOINTS

210.1 General

The type of piping joint used shall be suitable for the pressure-temperature conditions, and shall be selected giving consideration to joint tightness and mechanical strength under the service conditions. For example, they shall be able to sustain the maximum end force due to the internal pressure, i.e., the design pressure (psig) times the internal area of the pipe or piping component (sq in.); as well as any additional forces due to temperature expansion or contraction, or to the weight of pipe and contents.

211 WELDED JOINTS

211.1 General

All welds shall be made in accordance with the applicable requirements of Chapter V.

Welded joints may be used in any materials for which it is possible to qualify welding procedures, welders, and welding operators in conformance with the rules established in Chapter V.

211.2 Butt Welds

Butt welds are the preferred method for joining steel pipe. Butt welds may be made with or without backing or insert rings. When the use of backing rings will result in undesirable conditions, such as severe corrosion or erosion, then:

a) the backing ring shall be removed and the inside of the joint ground smooth, or

b) the joint shall be welded without backing rings or

c) consumable insert rings shall be used.

211.3 Socket Welds

Dimensions for socket welding piping joints shall conform to USAS B16.5 for flanges and USAS B16.11 for fittings and the weld dimensions shall be not less than the minimum dimensions given in Fig. 227.4.4B and C.

The use of socket welding piping joints where severe crevice corrosion or erosion may take place should be avoided.

211.4 Fillet Welds

Fillet welds shall have minimum dimensions as given in Fig. 227.4.4A.

211.5 Seal Welds

Seal welding of threaded joints in steel piping is permitted but the weld metal shall not be considered as contributing to the strength of the joint.

212 FLANGED JOINTS
(See Subdivision 208.1)

213 EXPANDED JOINTS

Expanded joints shall be used only in systems constructed from non-ferrous pipe and tubing where experience or tests have demonstrated that the joint is suitable for the conditions and where adequate provisions are made in the design to prevent separation of the joints.

214 THREADED JOINTS

Threaded joints may be used for joining piping components of steel, copper or aluminum pipe having at least the nominal wall thicknesses specified in Table 204.1. All pipe threads shall be taper pipe threads in accordance with USAS B2.1 except that pipe threads other than taper pipe threads may be used for piping components, where tightness of the joint depends upon a seating surface other than the threads, and where experience or tests have demonstrated that such threads are suitable for the conditions.

Threaded joints shall not be used in aluminum pipe in the annealed temper.

It is preferred that threaded piping not be used in sizes larger than 4 inch. nor where the joints are not visible for inspection.

The use of threaded joints where severe crevice corrosion or erosion may occur should be avoided.

215 FLARED, FLARELESS AND COMPRESSION JOINTS

Piping joints using flared, flareless, or compression type tubing fittings may be used subject to the following requirements:

(a) The joints shall not be located in concealed locations in buildings.

(b) Compression type joints shall be limited to 25 psig, and if above ground shall be suitably braced.

(c) The fittings and their joints shall be suitable for the tubing used. The tubing wall thickness, for example, should be such as to permit the assembly of safe joints when the manufacturer's recommended assembly techniques are followed.

(d) The manufacturer's pressure-temperature recommendations for the fittings shall be adequate for the service conditions anticipated.

(e) When unusual vibration, fatigue, cyclic conditions, low temperature, or thermal expansion are anticipated, a suitable quantity of the type and size of fitting to be used shall successfully meet performance tests designed to determine the safety of the joint under simulated service conditions. In the absence of service experience, the person responsible for the engineering design, shall establish the extent and number of tests which he considers necessary to satisfy himself that the fittings will meet the service conditions involved.

217 BRAZED JOINTS

Copper or brass tubing may be joined by brazing. Socket sleeve type joints may be used to join copper or brass tubing, in accordance with USAS B16.18 or USAS B16.22. Other socket sleeve type joints may be used where the brazed junction between pipe and sleeve extends the full depth of the socket. Fillet brazed or butted joints are not acceptable.

218 SLEEVE, COUPLED AND OTHER PROPRIETARY JOINTS

Coupling type, mechanical gland type and other proprietary type joints may be used within the manufacturer's pressure-temperature recommendations, provided adequate provision is made to prevent separation of the joints and provided a prototype joint has been subjected to performance tests to determine the safety of the joint under simulated service conditions. When vibration, fatigue, cyclic conditions, thermal expansion, etc., are anticipated the applicable conditions shall be incorporated in the tests.

PART 5: EXPANSION, FLEXIBILITY, STRUCTURAL ATTACHMENTS, SUPPORTS, AND RESTRAINTS

219 EXPANSION AND FLEXIBILITY

219.1 General

All piping shall meet the following requirements with respect to thermal expansion and flexibility:

(a) No formal analysis is required in systems which meet one of the following criteria:

(1) They are duplicates of successfully operating installations or replacements of systems with a satisfactory service load.

(2) They can be adjudged adequate by comparison with previously analyzed systems.

(3) For a two-anchor system of uniform pipe size, the following relationship is satisfied:

$$\frac{DY}{(L-U)^2} \leq 0.03$$

Where D = Nominal pipe size, inches

$Y = \sqrt{(e_x)^2 + (e_y)^2 + (e_z)^2}$ in which e_x is the maximum calculated thermal expansion or contraction of the exposed piping in the X direction, inches.

e_y is the maximum calculated thermal expansion or contraction of the exposed piping in the Y direction, inches.

e_z is the maximum calculated thermal expansion or contraction of the exposed piping in the Z direction, inches.

L = actual total length of the center line of the main between anchors or other relatively fixed points on each side of the span, feet.

U = straight line distance between anchors or other relatively fixed points on each side of the span, feet.

(b) All systems not meeting the above criteria shall be analyzed by simplified, approximate, or comprehensive methods of analysis that are appropriate for the specific case. (See Division 319 of ASA B31.3.)

219.5 Flexibility

Flexibility shall be provided by the use of bends, loops, or offsets; or provision shall be made to absorb thermal changes by the use of slip type expansion joints or couplings, by the use of bellows type expansion joints, or by the use of "ball" or "swivel" joints. If expansion joints are used, anchors or ties of sufficient strength and rigidity shall be installed to provide for end forces resulting from fluid pressure and other causes.

221 DESIGN OF PIPE SUPPORTING ELEMENTS

221.1 General

Piping shall be supported in a substantial and workmanlike manner, so as to prevent or damp out excessive vibration, and shall be anchored sufficiently to prevent undue strains on connected equipment. Pipe hangers and supports shall conform to the requirements of MSS SP 58.

Supports, hangers, and anchors should be installed so as not to interfere with the free expansion and contraction of the piping between anchors. Suitable spring hangers, sway bracing, etc., shall be provided where necessary. All parts of the supporting equipment shall be designed and installed so that they will not be disengaged by movement of the supported piping.

If the design of the piping system requires supports or anchors which are welded directly to the pipe, it is preferable that such supports, or anchors consist of members which completely encircle the pipe.

221.5 Maximum Spacing of Supports

It is recommended that the maximum spacing between pipe supports for straight runs of standard wall and heavier pipe does not exceed the values shown in the table below. The recommended spacing is based on a combined bending and shear stress of 1500 psig when pipe is filled with water and the pitch of the line is such that a sag of 0.1 inch between supports is permissible. This spacing does not apply where there are concentrated loads between supports, such as valves and components of comparable weight.

Table 221.5

Nom. Pipe Size, in.	1	1½	2	2½	3	4	5	6	8	10	12	14	16	18	20	24
Max. Span Feet	7	9	10	11	12	14	16	17	19	22	23	25	27	28	30	32

PART 6: SYSTEMS DESIGN REQUIREMENTS PERTAINING TO SPECIFIC PIPING SYSTEMS

222 FUEL GAS PIPING SYSTEMS

222.1 Valves

Manual shut-off valves shall be provided at appropriate points in larger piping systems and at each unit of gas utilization equipment. An exterior shut-off valve to permit turning off the gas supply to each building in an emergency shall be provided. The emergency shut-off valves shall be plainly marked as such and their locations posted at appropriate points.

222.2 Pressure Controlling Devices (Pressure Regulators)

222.2.1 Each piping system supplied from a higher pressure source shall be equipped with suitable pressure controlling devices (regulators) designed to meet the pressure and other service conditions (such as capacity) under which they will operate.

The bodies of pressure controlling devices shall conform to the requirements of this code for valves in comparable service.

A shut-off valve shall be installed upstream of every pressure regulator.

Suitably valved by-passes should be placed around gas pressure regulators where continuity of service is imperative.

All service regulator vents and relief vents, where required, shall terminate in the outside air in fittings resistant to rain, ice (in areas where freezing temperatures can occur) and insects. The open end of the vent shall be located where, if a regulator failure resulting in the release of gas occurs, the gas can escape freely into the atmosphere and away from any openings into the buildings. At locations where service regulators might be submerged during floods, either a special anti-flood type breather vent fitting shall be installed, or the vent line shall be extended above the height of the expected flood waters.

222.2.2 A suitable pressure relieving or pressure limiting device shall be installed on every piping system which has a maximum working pressure rating less than that of the gas source if the gas source is operating at a pressure of more than 10 psig. Such overpressure protective devices shall be designed and set to prevent the pressure in the piping system being protected from exceeding that value which would cause unsafe operation of any connected and properly adjusted gas utilization equipment but the pressure shall not exceed, in any event, 110 per cent of the maximum working pressure rating of the system being protected. The pressure relieving or pressure limiting device may consist of any one of the following:

(a) Spring loaded relief valve of a type meeting the provisions of the ASME Unfired Pressure Vessel Code.

(b) Pilot loaded back-pressure regulator used as a relief valve so designed that failure of the pilot system or control lines will cause the

regulator to open.

(c) Weight loaded relief valve.

(d) A monitoring regulator installed in series with the primary pressure regulator.

(e) A series regulator installed upstream from the primary regulator and set to continuously limit the pressure on the inlet of the primary regulator to the maximum working pressure of the downstream piping system.

(f) An automatic shut-off device installed in series with the primary pressure regulator and set to shut-off when the pressure on the downstream piping system reaches the maximum working pressure or some other pre-determined pressure less than the maximum working pressure. This type of device must be designed so that it will remain closed until manually reset.

(g) A liquid seal relief device that can be set to open accurately and consistently at the desired pressure.

The above devices may be installed as an integral part of the primary regulator or as separate units. If separate pressure relieving or pressure limiting devices are installed, they shall meet the requirements of Subdivision 222.3 and 222.4.

222.2.3 The basic requirements of Paragraph 222.2.2 will be met and a piping system deemed to have adequate over-pressure protection when there are two acceptable devices (a primary pressure regulator plus one other device), each limiting the pressure to a value that does not exceed the maximum working pressure of the downstream system, both of which must fail simultaneously in order to over pressure the downstream system. The above requirements are based, of course, on the assumption that the pressure regulating, limiting and/or relieving devices are properly maintained and that the necessary inspection procedures are devised or suitable instrumentation installed to detect failures or malfunctions of such devices and that replacements or repairs are promptly made.

222.2.4 Notwithstanding the requirements of Paragraphs 222.2.2 and 222.2.3, no pressure relieving or limiting device is required if the gas does not contain materials that could seriously interfere with the operation of the primary pressure regulator and if the operating pressure of the gas source is 60 psig or less and if the primary pressure regulator is a service-type regulator having all of the following design features or characteristics:

(a) Pipe connections to the primary regulator do not exceed 2 inches nominal diameter.

(b) It is self-contained with no external static or control lines.

(c) It has a single port valve with an orifice diameter no greater than that recommended by the manufacturer for the maximum gas pressure at the regulator inlet.

(d) The valve seat is made of resilient material designed to withstand abrasion of the gas, impurities in the gas and cutting by the valve and to resist permanent deformation when it is pressed against the valve port.

(e) It is capable, under normal operating conditions, of regulating the downstream pressure within the necessary limits of accuracy and of limiting the discharge pressure under no-flow conditions to 150 per cent or less of the discharge pressure maintained under flow conditions.

If all above conditions do not exist, the requirements of Paragraphs 222.2.2 and 222.2.3 shall be met.

222.2.5 Notwithstanding the requirements of Paragraphs 222.2.2 and 222.2.3, a first-cut pressure regulator with its own over-pressure protective device shall be used in addition to a primary pressure regulator and an over-pressure protective device when one of the following conditions exists:

(a) The operating pressure of the gas source exceeds 60 psig and the discharge pressure of the primary regulator is 10 psig or less, or

(b) The operating pressure of the gas source exceeds 300 psig and the discharge pressure of the primary regulator is 60 psig or less but more than 10 psig.

Under condition (a), above, the first-cut regulator shall be installed upstream of the primary regulator and shall be set to maintain a discharge pressure of 60 psig or less. Furthermore, a service-type regulator without any over-pressure protective device may be used in lieu of the primary pressure regulator and an over-pressure protective device if the conditions outlined in Paragraph 222.2.4 exist.

Under condition (b), above, the first-cut regulator shall be set to maintain a discharge pressure of 300 psig or less.

222.2.6 The requirements for pressure control and over-pressure protective devices outlined in Subdivision 222.2 are summarized in the following table: (NOTE: Table reproduced on Page 18).

222.3 Instrument, Control and Sampling

222.3.1 *General*

The requirements given in Subdivision 222.3 apply to the design of instrument, control, and sampling piping for safe and proper operation of the piping itself and do not cover design of piping to secure proper functioning of instruments for which the piping is installed.

Subdivision 222.3 does not apply to per-

Table 222.2.6

Summary of Pressure Control and Over Pressure Protection Requirements

(1)	(2)	(3)	(4)	(5)
	Discharge Pressure of Primary Regulator			
Operating Pressure of Gas Source	10 psig or Less	60 psig or Less More Than 10 psig	300 psig or Less More Than 60 psig	More Than 300 psig
10 psig or Less	Primary regulator only (See 222.2.1)	–	–	–
60 psig or Less More Than 10 psig	Primary regulator plus Protective device* (See 222.2.2 and 222.2.3)	Primary regulator only (See 222.2.1)	–	–
300 psig or Less More Than 60 psig	First-cut regulator plus Protective device and Primary regulator plus Protective device* (See 222.2.5)	Primary regulator plus Protective device (See 222.2.2 and 222.2.3)	Primary regulator only (See 222.2.1)	–
More Than 300 psig	First-cut regulator plus Protective device and Primary regulator plus Protective device (See 222.2.5)	First-cut regulator plus Protective device and Primary regulator plus Protective device (See 222.2.5)	Primary regulator plus Protective device (See 222.2.2 and 222.2.3)	Primary regulator only (See 222.2.1)

*No protective device required if the conditions listed in 222.2.4 exist.

manently closed piping systems furnished with instruments, such as fluid-filled temperature-responsive devices.

222.3.2 *Design Requirements*

(a) Take-off connections and attaching bosses, fittings, or adapters shall be made of suitable material and shall be capable of withstanding the maximum service pressure and temperature of the piping or equipment to which they are attached. For take-off connections which are subject to substantial bending stresses, the nominal size of the pipe or tubing shall not be less than 3/8 inch.

(b) A shut-off valve shall be installed in each take-off line as near as practicable to the point of take-off. Blowdown valves shall be installed where necessary for the safe operation of piping, instruments, and equipment. All valves shall be capable of withstanding the maximum service pressure and temperature of the piping system or equipment to which the take-off is attached except as provided for in (c).

(c) Brass, aluminum, or copper pipe or tubing shall not be used for metal temperatures greater than those permitted in this code for the specific material, except that they may be used in dead-end instrument and control piping which is connected to piping or equipment having design temperatures up to 450 F, provided at least 5 ft of uninsulated steel pipe or tubing is interposed between the take-off connection and the brass pipe or copper pipe or tubing.

(d) Piping subject to clogging from solids or deposits shall be provided with suitable connections for cleaning and shall have an inside diameter of 3/8 in. or larger in instrument piping or an inside diameter of 3/16 in. or larger in control piping.

(e) Pipe or tubing of diameters smaller than the minimum diameters required under this paragraph may be specified by the manufacturer of the instrument, control apparatus, or sampling device provided that the safety of the smaller pipe or tubing as installed is at least equal to that otherwise required under the Code.

(f) Piping which may contain liquids shall be protected by heating or other adequate means from damage due to freezing.

(g) Piping in which liquids may accumulate shall be provided with drains or drips.

(h) The arrangement of piping and supports as required under Division 221 shall provide for safety under working stresses and protection from detrimental sagging and external mechanical injury. Protection against abuse and exposure to unusual service conditions from sources other than those due to pressure, temperature and vibration shall also be provided for in the arrangement.

222.4 Relief and Pressure Limiting Devices

222.4.1 *General*

All pressure relief or pressure limiting devices shall:

(a) Be constructed of materials such that the operation of the device will not normally be impaired by corrosion of external parts by the atmosphere or of internal parts by the gas.

(b) Be designed and installed so that they can be readily operated to determine if the valve is free. Furthermore, the devices shall be designed and installed so that they can be tested to determine the pressure at which they will operate and for leakage when in the closed position.

222.4.2 *Relief Valves*

Each pressure relieving device, or group of such devices, installed to protect a piping system shall be set to operate to prevent the pressure from exceeding the maximum allowable working pressure plus ten per cent.

The discharge stacks, vents, or outlet parts of all pressure relief devices shall be located where gas can be discharged into the atmosphere without undue hazard. Where required to protect devices, the discharge stacks, or vents, shall be protected with rain caps to preclude the entry of water.

The openings, pipe and fittings located between the system to be protected and the pressure relieving device, shall be of adequate size to prevent hammering of the valve and to prevent impairment of relief capacity. The discharge stack or vent line shall be the same size as or larger than the outlet of the pressure relieving device.

Precautions shall be taken to prevent unauthorized operation of any shut-off valve which will make a pressure relief valve inoperative. Acceptable methods for complying with this provision are:

(a) Lock the shut-off valve in the open position. Instruct authorized personnel of the importance of not inadvertently leaving the shut-off valve closed and of being present during the entire period that the shut-off valve is closed so that they can lock it in the open position before they leave the location.

(b) Install duplicate relief valves, each having adequate capacity by itself to protect the system, and arrange the isolating valves or 3-way valve so that mechanically it is possible to render only one safety device inoperative at a time.

222.4.3 *Pressure Limiting Devices*

Each pressure limiting device shall be set to prevent the pressure in the facility which it protects from exceeding the maximum allowable working pressure plus ten per cent.

Precautions shall be taken to prevent unauthorized operation of any valve which will make pressure limiting devices inoperative. This provision applies to relief valves, isolating valves, by-pass valves, and valves on control or float lines which are located between the pressure limiting device and the system which the device protects.

Where the safety device consists of an additional regulator which is associated with or functions in combination with one or more regulators in a series arrangement to control or limit the pressure in a piping system, suitable checks shall be made to determine that the equipment will operate in a satisfactory manner to prevent any pressure in excess of the established maximum allowable working pressure of the system should any one of the associated regulators malfunction or remain in the wide open position.

Special attention shall be given to control lines. All control lines shall be protected from falling objects, excavations by others, or other foreseeable causes of damage and shall be designed and installed to prevent damage to any one control line from making both the regulator and the overpressure protective device inoperative.

If automatic shut-off valves are used, they shall be of the manual reset type.

222.5 Back Pressure and Low Pressure Protective Devices

222.5.1 *Back Pressure Protection*

When the design of utilization equipment connected is such that air or oxygen may be forced into the gas supply system, suitable protective devices shall be installed. Gas and air combustion mixers incorporating double diaphragm "zero" or "atmosphere" governors or regulators require no further protection unless connected directly to compressed air or oxygen at pressures of 5 psig or more.

Suitable protective devices include but are not limited to the following:

(a) Check valves.

(b) Three-way valves (of a type that completely closes one side before starting to open the other side).

(c) Reverse flow indicators controlling positive shut-off valves.

222.5.2 *Low Pressure Protection*

A suitable protective device shall be installed between the meter and the utilization equipment if the operation of the equipment is such (i.e. gas compressors) that it may produce a vacuum or a dangerous reduction in gas pressure at the meter. Such devices include but are not limited to mechanical, diaphram-operated, or electrically-operated low-pressure shut-off valves.

CHAPTER III

MATERIALS

223 MATERIALS – GENERAL REQUIREMENTS

223.1 General

223.1.1 Materials shall be classified into one of four categories, as shown below, in-so-far as use under this Code is concerned.

(a) Materials which conform to standards or specifications listed here-in.

(b) Materials which do not vary materially from standards or specifications listed here-in.

(c) Materials conforming to standards or specifications not listed here-in, but which are included in USAS B31.3.

(d) Materials which do not conform to any standards or specifications listed here-in nor to any standards or specifications listed in USAS B31.3.

223.1.2 Materials which conform to standards or specifications listed in Tables 202.3.1 or 226.1 may be used for appropriate applications, as prescribed and limited by this Code, without further qualification.

223.1.3 Materials which do not vary materially from standards or specifications listed in Tables 202.3.1 or 226.1, but which meet the minimum requirements of this Code for similar materials with respect to quality and testing requirements, may be used for appropriate applications as prescribed and limited by this Code without further qualification. This paragraph shall not be construed to permit deviations which would tend to affect weldability or ductibility adversely. If deviations tend to reduce strength, full allowance for the reduction shall be provided in the design.

223.1.4 Materials which conform to standards or specifications listed in USAS B31.3 may be used for appropriate applications even though the applicable standard or specification is not listed here-in, provided that all of the applicable qualifications and limitations prescribed in USAS B31.3 for such materials are met.

223.1.5 Materials which do not conform to any standards or specifications listed herein, nor to any standards or specifications listed in USAS B31.3, shall be used only after they have been approved for the intended use by USA Standards Committee B31 under USASI procedures.

When requesting such approval, the material should be identified, if possible, with an ASTM specification. If the material cannot be identified with an ASTM specification, data regarding the chemical composition and physical properties of the material should be submitted with the request for approval. No specific quantity of data is required, but it should be sufficient to characterize the suitability of the material for the proposed application. Such data may include the following:

*(1) Tensile strength
*(2) Yield strength
*(3) Elongation
*(4) Chemical composition
*(5) Manufacturing process
(6) Hardness
(7) Creep stress
(8) Rupture stress
(9) Any heat treatment
(10) Any welding process
(11) Any surface finish
(12) Pertinent data about possible brittle behavior

*These kinds of data are required for any material.

223.1.6 Pipe or materials of unknown origin or specifications may be used provided careful visual inspection indicates that it is in good condition free from defects that would cause leakage and provided further that if the pipe or material is to be welded, it shall satisfactorily pass weldability tests. Furthermore, the allowable stress values for such unknown pipe or materials shall not exceed 50 per cent of the values listed in Table 202.3.1 for a similar material having the lowest allowable stress.

223.1.7 Used pipe or materials of known specifications may be used provided they have been thoroughly cleaned and visually inspected to determine that they are in good condition and do

not contain any defects which might impair strength or tightness.

223.2 LIMITATIONS ON MATERIALS

223.2.1 *General*

In addition to the limitations listed in this Chapter, the limitations prescribed in Chapter II Part 3 are also applicable.

223.2.5 *Nodular Iron*

Components of nodular iron having dimensions conforming to USAS B16.1, B16.2, B16.5, and API 604 may be used at the following maximum pressure-temperature ratings at temperatures between minus 20 F and 450 F.

Dimensions used	Maximum Rating
Class 125 C.I. (B16.1)	80% of 150 lb Carbon Steel
Class 250 C.I. (B16.2)	80% of 300 lb Carbon Steel
150 to 600 lb Steel, inclusive (B16.5 or API 604)	80% of Carbon Steel Rating

These ratings are applicable to valves providing the valves in other respects merit these ratings. It is recognized that components made to the Class 125 and Class 250 standards or to API Standard 604 may be thicker than those made to the 150 lb and 300 lb standards, respectively. In the case of these thicker components, the additional wall thickness may be considered as additional corrosion allowance.

Nodular iron shall not be used for pressure containing parts at pressures above 1000 psi. Welding shall not be employed either in fabrication of nodular iron pressure containing components or in their assembly as part of a piping system.

223.2.7 External or internal coatings or linings of various types may be used on pipe or components conforming to the requirements of this Code, but these coatings or linings shall not be considered as adding strength.

223.2.8 Components which are principally composed of non-metallic materials shall not be used for pressure-containing parts of fuel gas piping systems except as permitted in Subdivision 205.4.

225 MATERIAL LIMITATIONS APPLIED TO MISCELLANEOUS COMPONENTS

225.3 Gaskets

Material for gaskets shall be capable of withstanding the design pressure of the piping system and be suitable for the design temperature.

Gaskets subjected to design temperatures above 250 F shall be of non-combustible material.

Metallic, asbestos composition, metal-jacketed asbestos, or other type gaskets may be used subject to the limitation of Subdivision 208.4. Metallic gaskets shall not be used with 150 lb standard or lighter flanges.

Gaskets used for insulating flanges shall be suitable for the temperature, moisture, and other conditions where they will be used.

225.4 Bolting

The materials used for bolts and nuts shall conform to the requirements of Subdivision 208.5.

CHAPTER IV

DIMENSIONAL REQUIREMENTS

226 DIMENSIONAL REQUIREMENTS FOR STANDARD AND NON-STANDARD PIPING COMPONENTS

226.1 Standard Piping Components

Dimensions of piping components shall comply with the dimensional standards listed in Table 226.1 or with the dimensional requirements of the standards listed in Tables 202.3.1, except that non-standard piping components may be used provided that the requirements of Subdivision 226.2 are met.

Table 226.1

Dimensional Standards

(Note: Standards approved for use under this Code, and the names and addresses of the sponsoring organizations, are shown in Appendix A. It is not practical to refer to specific editions of each standard throughout the Code text; but instead, the specific edition references are shown in Appendix A. Appendix A will be revised at intervals as needed.)

Standard	Designation
BOLTING	
Square and Hex Bolts and Screws, Including Hex Cap Screws and Lag Screws	USAS B18.2.1
Square and Hex Nuts	USAS B18.2.2
FITTINGS, VALVES, FLANGES AND GASKETS	
Cast-Iron Flanges and Flanged Fittings, 25, 125, 250 and 800 lb	USAS B16.1
Malleable-Iron Screwed Fittings, 150 lb and 300 lb	USAS B16.3
Cast-Iron Screwed Fittings, 125 and 250 lb	USAS B16.4
Steel Pipe Flanges and Flanged Fittings	USAS B16.5
Wrought Steel Buttwelding Fittings	USAS B16.9
Face-to-Face and End-to-End Dimensions of Ferrous Valves	USAS B16.10
Forged Steel Fittings, Socket-Welding and Threaded	USAS B16.11
Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads	USAS B16.14
Cast Bronze Screwed Fittings, 125 lb and 250 lb	USAS B16.15
Cast Bronze Solder-Joint Pressure Fittings	USAS B16.18
Ring-Joint Gaskets and Grooves for Steel Pipe Flanges	USAS B16.20
Nonmetallic Gaskets for Pipe Flanges	USAS B16.21
Wrought Copper and Bronze Solder-Joint Pressure Fittings	USAS B16.22
Bronze Flanges and Flanged Fittings, 150 and 300 lb	USAS B16.24
Buttwelding Ends for Pipe, Valves, Flanges, and Fittings	USAS B16.25
Wrought Steel Buttwelding Short Radius Elbows and Returns	USAS B16.28
Specification for Wellhead Equipment	API 6A
Specification for Steel Gate, Plug, Ball, and Check Valves for Pipeline Service	API 6D
Flanged and Butt-Welding-End Steel Gate and Plug Valves for Refinery Use	API 600
Metallic Gaskets for Refinery Piping (Double-Jacketted Corrugated and Spiral Wound)	API 601
Flanged Nodular Iron Gate and Plug Valves for Refinery Use	API 604
Specifications for Unions and Pipe Fittings, 300 lb Pressure	AAR M-404

Table 226.1 – Dimensional Standards (cont'd)

Standard	Designation
Finishes for Contact Faces of Connecting End Flanges of Ferrous Valves and Fittings	MSS SP-6
Spot-Facing Standard	MSS SP-9
Standard Marking System for Valves, Fittings, Flanges, and Unions	MSS SP-25
125-lb Bronze Gate Valves	MSS SP-37
Steel Pipeline Flanges	MSS SP-44
By-Pass and Drain Connection Standard	MSS SP-45
Steel-Butt Welding Fittings (26 inch. and Larger)	MSS SP-48
150 lb Corrosion Resistant Cast Flanges and Flanged Fittings	MSS SP-51
Pipe Hangers and Supports	MSS SP-58
PIPE AND TUBES	
Wrought-Steel and Wrought-Iron Pipe	USAS B36.10
Ductile-Iron Pipe, Centrifugally Cast, in Metal Molds or Sand-Lined Molds for Gas	USAS A21.52
MISCELLANEOUS	
Unified Screw Threads	USAS B1.1
Pipe Threads (Except Dryseal)	USAS B2.1

226.2 Non-Standard Piping Components

The dimensions for non-standard piping components shall be such as to provide strength and performance equivalent to standard components, except as permitted under Division 204. For convenience, dimensions should conform to those of comparable components.

226.3 Threads

The dimensions of all piping connection threads not otherwise covered by a governing component standard or specification, shall conform to the requirements of applicable standards listed in Table 226.1.

CHAPTER V

FABRICATION, ASSEMBLY AND ERECTION

227 WELDING

227.1 General

Althoung there are many widely acceptable methods of welding, the welding requirements in this chapter of the Code cover primarily manual metal arc welding and oxy-acetylene welding of ferrous pipe and fitting joints in piping systems and connections to apparatus or equipment because these are the most widely used welding methods and weldable materials. This limitation in coverage is not to be construed, however, as a restriction on the welding methods or weldable materials that can be used under this Code. Any appropriate welding method or weldable material can be used if the applicable requirements of Division 223, Subdivisions 227.5 and 227.6, and Paragraph 228.2.4 are met.

227.2 Material

227.2.1 *Filler Material*

All filler material shall conform to the appropriate AWS-ASTM specification.

227.2.2 *Backing Rings*

Backing rings may be used provided the satisfactory use of such materials has been determined by the procedure qualification and provided further that the conditions described in Subdivision 211.2 do not exist.

227.3 Preparation

227.3.1 *Butt Welds*

(a) *End Preparation.*

(1) Oxygen or arc cutting is acceptable only if the cut is reasonably smooth and true and all slag is cleaned from the flame cut surfaces. Discoloration which may remain on the flame cut surface is not considered to be detrimental oxidation.

(2) Butt-welding end preparation contained in ASA B16.25 or any other end preparation which meets the procedure qualification is acceptable. (For convenience the basic bevel angles taken from B16.25 are shown in Fig. 227.3.1A.)

(b) *Cleaning.*

Surfaces for welding shall be clean and shall be free from paint, oil, rust, scale, or other material which is detrimental to welding.

(c) *Alignment.*

The ends of piping components to be joined shall be aligned as accurately as is practicable within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness. Alignment shall be preserved during welding. Where ends are to be joined and the internal misalignment exceeds 1/16 inch, it is preferred that the component with the wall extending internally be internally trimmed (see Fig. 227.3.1B), so that adjoining internal surfaces are approximately flush. However, this trimming shall not result in a piping component wall thickness less than the minimum required thickness plus corrosion and other allowances.

(d) *Spacing.*

The root opening of the joint shall be as given in the procedure specification.

227.3.2 *Fillet Welds*

Piping components which are to be joined in a manner which includes fillet welding shall be prepared in accordance with applicable

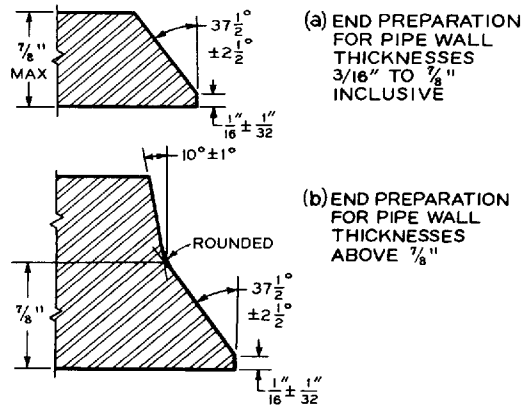


FIG. 227.3.1A BUTT-WELDING END PREPARATION

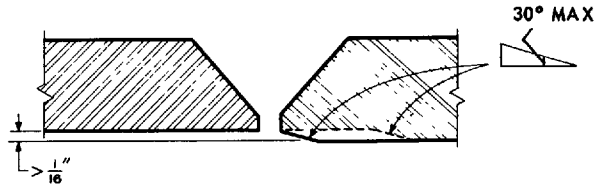
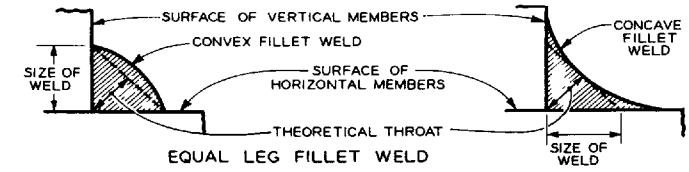
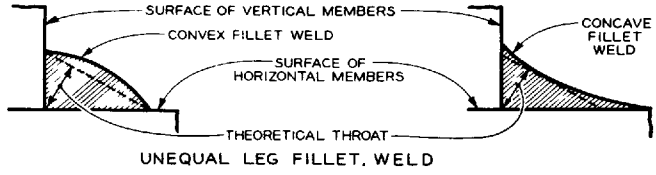


FIG. 227.3.1B INTERNAL MISALIGNMENT

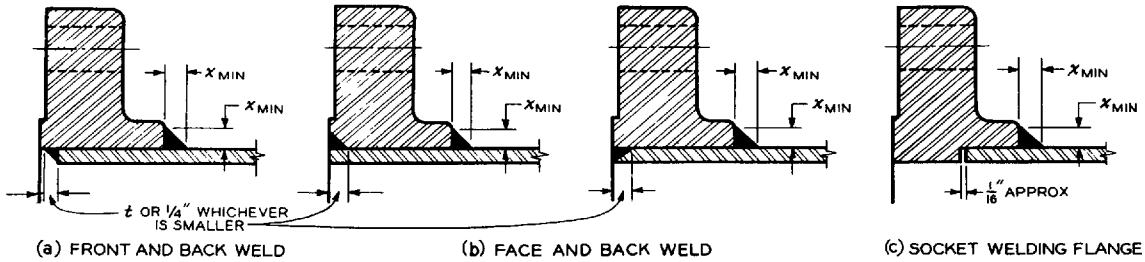


NOTE: THE "SIZE" OF AN EQUAL LEG FILLET WELD IS THE LENGTH OF THE LARGEST INSCRIBED RIGHT ISOSCELES TRIANGLE. (THEORETICAL THROAT = 0.707 x SIZE)



NOTE: THE "SIZE" OF AN UNEQUAL LEG FILLET WELD IS THE LEG LENGTHS OF THE LARGEST RIGHT TRIANGLE WHICH CAN BE INSCRIBED WITHIN THE FILLET WELD CROSS SECTION (e g , 1/2" x 1")

FIG. 227.4.4A FILLET WELD SIZE



x_{MIN} = 1.4 t OR THE THICKNESS OF THE HUB, WHICHEVER IS SMALLER, BUT NOT LESS THAN 1/8" (SEE DIVISION 304 FOR DEFINITION OF t)

FIG. 227.4.4B WELDING DETAILS FOR SLIP-ON AND SOCKET-WELDING FLANGES
SOME ACCEPTABLE TYPES OF FLANGE ATTACHMENT WELDS

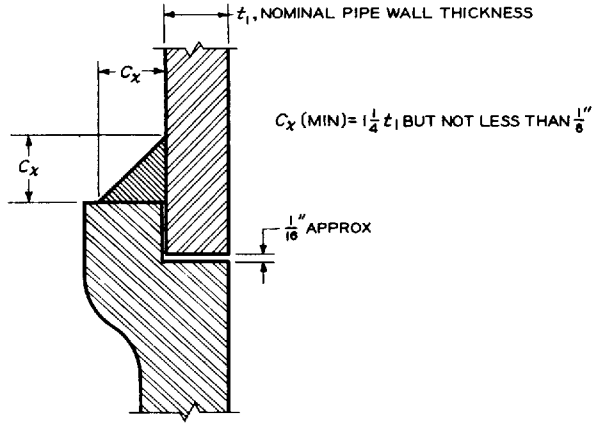


FIG. 227.4.4C MINIMUM WELDING DIMENSIONS REQUIRED FOR SOCKET WELDING COMPONENTS OTHER THAN FLANGES

provisions and requirements of Par. 227.3.1. For typical details see Fig. 227.4.4A, B and C.

227.4 Procedure

227.4.1 *General*

No welding shall be done if there is impingement of any rain, snow, sleet or high wind on the weld area.

227.4.2 *Girth Butt Welds*

(a) Butt joints may be made with a single vee, double vee, or other suitable type of groove, with or without backing rings.

(b) Tack welds shall be made by a qualified welder or shall be removed. Tack welds which are not removed shall be made with a filler metal which is the same as or equivalent to the filler metals to be used for the first pass. Tack welds which have cracked shall be removed.

(c) If the external surfaces of the two components are not aligned, the weld shall be tapered between the two surfaces.

(d) Welds shall comply with the following limitations as to imperfections, within the capabilities of the type of examination used, and for types of imperfections required to be evaluated:

(1) *Cracks:* None permitted.

(2) *Incomplete Penetration and Lack of Fusion:* The total joint penetration shall not be less than the thinner of the two components being joined, except to the extent that incomplete root penetration is permitted. The depth of incomplete root penetration or lack of fusion at the weld root, shall not exceed 1/32 inch or half the thickness of the weld reinforcement, whichever is smaller. The total length of such incomplete root penetration or lack of fusion at the root shall not exceed 1½ inches in any 6 inches of weld length.

Unless otherwise specified by the engineering design, welds on which 100 per cent radiography is specified, shall have complete joint penetration.

(3) *Weld Reinforcement and Undercutting:* A butt weld shall not have an undercut exceeding 1/32 inch deep. The thickness of weld reinforcement shall not exceed the following (considering the thinner component being joined):

Component Thickness (in.)	Reinforcement Thickness, Max (in.)
½ and under	1/8
Over ½ through 1	5/32
Over 1	3/16

For double welded joints this limitation on reinforcement shall apply to each surface of the weld separately.

Within the above limitations, the surface of the weld shall fair into the base metal of the components being welded.

227.4.3 *Longitudinal Butt Welds*

Any longitudinal butt weld in a piping component not made in accordance with a standard listed in Table 202.3.1 (See Appendix D) shall conform to the following:

(a) The weld shall be single or double butt welded, using a single vee, double vee, or other suitable type of groove.

(b) Tack welds shall either be made by a qualified welder using the same procedure as the completed weld or shall be removed. Tack welds which are not removed should be made with a filler metal which is the same as or equivalent to the filler metal to be used for the first pass. Tack welds which have cracked shall be removed.

(c) Welds shall comply with the following limitations as to imperfections, for the type of examination used and for types of imperfections required to be evaluated. The methods of examination are described by Subdivision 236.4. The types and extent of examination required are specified in Subdivision 236.5.

(1) *Cracks:* None permitted.

(2) *Incomplete penetration and Lack of Fusion:* None Permitted.

(3) *Undercutting:* Butt welds shall be free from undercutting, and finished weld surfaces shall merge smoothly into the base metal surface at the toe.

(4) *Weld Reinforcement:* The thickness of the weld reinforcement shall be 1/16 inch to 1/8 inch. For double welded joints this limitation on reinforcement shall apply to each surface of the weld separately.

227.4.4 *Fillet Welds*

Fillet welds may vary convex to concave. The size of a fillet weld is determined as shown in Fig. 227.4.4A. Typical minimum fillet weld details for slip-on flanges and socket-welding components are shown in Figs. 227.4.4B and 227.4.4C. The limitations on cracks and undercutting set forth in 227.4.2(d) for girth welds are also applicable to fillet welds.

227.4.5 *Seal Welds*

If a seal welding of threaded joints is performed, all exposed threads shall be covered by the seal weld. Seal welding shall be done by qualified welders.

227.4.6 *Welded Branch Connections*

(a) Fig. 227.4.6A, 227.4.6B, and 226.4.6C show typical details of branch connections, with and without added reinforcement. However, no attempt has been made to show all acceptable types of construction and the fact that a certain type of construction is illustrated does not indicate that it is recommended over other types not illustrated.

(b) Fig. 227.4.6D shows basic types of weld attachments used in the fabrication of branch connections. The location and minimum size of these attachment welds shall conform to the requirements of Par. 227.4.6.

The notations and symbols used in Fig. 227.4.6D are as follows:

t_c = 0.7 t_n but not less than ¼ inch.

t_n = nominal thickness of branch wall less corrosion allowance, inches.

t_e = nominal thickness of reinforcing element (ring or saddle), inches. (t_e = 0 if there is no added reinforcement.)

t_{min} = the smaller of t_n or t_e.

(c) Branch connections (including specially made integrally reinforced branch connections fittings) which abutt the outside surface of the run wall, or which are inserted through an opening cut in the run wall, shall have opening and branch contour to provide a good fit and shall be attached by means of fully penetrated groove welds.

(d) In branch connections having reinforcement pads or saddles, the reinforcement shall be attached by welds at the outer edge and at the branch periphery.

(e) When rings or saddles are used, a vent hole shall be provided (at the side and not at the crotch) in the ring or saddle to reveal leakage in the weld between branch and main run and to provide venting during welding and heat treating operations. Rings or saddles may be made in more than one piece if the joints between the pieces have adequate strength and if each piece is provided with a vent hole. A good fit shall be provided between reinforcing rings or saddles and the parts to which they are attached.

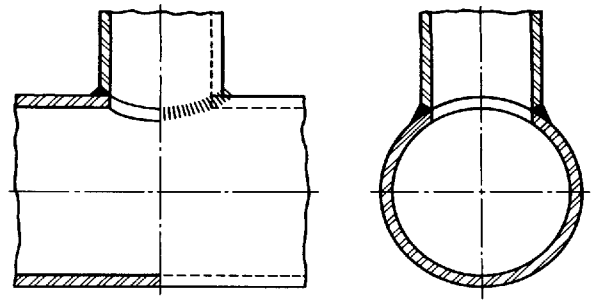


FIG. 227.4.6A TYPICAL WELDED BRANCH CONNECTION WITHOUT ADDITIONAL REINFORCEMENT

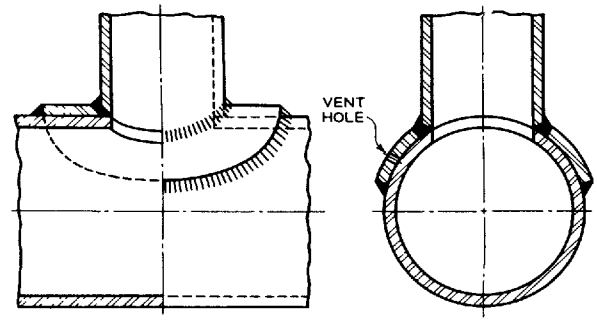


FIG. 227.4.6B TYPICAL WELDED BRANCH CONNECTION WITH ADDITIONAL REINFORCEMENT

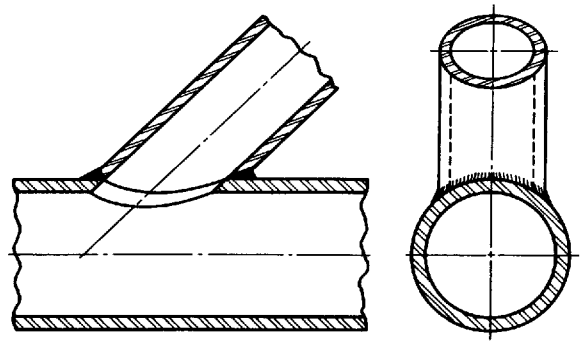


FIG. 227.4.6C TYPICAL WELDED ANGULAR BRANCH CONNECTION WITHOUT ADDITIONAL REINFORCEMENT

227.4.7 *Thermal Treatment*

Heat treatment for welds shall be in accordance with Division 231.

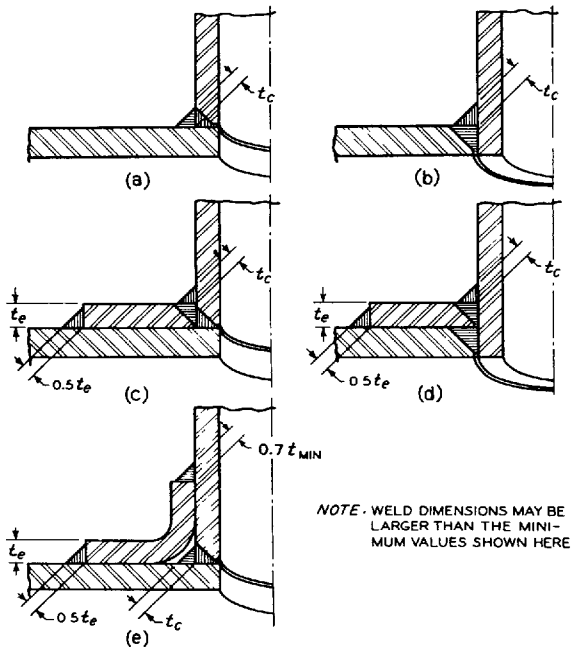


FIG. 227.4.6D SOME ACCEPTABLE TYPES OF WELDED BRANCH ATTACHMENT DETAILS SHOWING MINIMUM ACCEPTABLE WELDS

227.5 Qualification

227.5.1 *General*

Welding procedures and persons doing welding shall be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code or API 1104.

227.5.3 *Welding Responsibility*

Each employer is responsible for the welding done by personnel of its organization, and shall conduct the required qualification test to qualify the welding procedures, and the welders or welding operators.

227.5.4 *Qualification by Others*

To avoid duplication of qualification tests of procedures, or welders or welding operators, the procedures, welders or welding operators qualified as required above by one employer may be accepted by another employer on piping using the same or an equivalent procedure wherein the essential variables are within the limits established in Section IX, ASME Boiler and Pressure Vessel Code or in API Std. 1104. An employer accepting such qualification tests by another employer shall obtain a copy (from the previous employer) of the pertinent test records. The employer shall then prepare and sign the record required in Paragraph 227.6 accepting full responsibility for the procedure or welder or welding operator.

227.5.5 *Test Joint*

Test joints for both procedure qualification and performance qualification shall be made as groove welds in pipe in one or more of the specified basic qualification test positions.

227.5.6 *Performance Requalification*

Renewal of a Performance Qualification is required (1) when a welder has not used the specific process (e.g., metal arc, gas) to weld either ferrous or non-ferrous pressure piping components for a period of three months or more, or (2) when there is a specific reason to question his ability to make welds that meet the Performance Qualification requirements. Renewal of qualification under stipulation (1) need be made in only a single pipe wall thickness.

227.6 Qualification Records

The employer shall maintain suitable certified records of the procedures used and the welders or welding operators employed by him showing dates of qualification, results of tests and the identification symbol assigned to each welder or welding operator.

227.7 Defect Repairs

All defects in welds requiring repair, shall be removed by flame or arc gouging, grinding, chipping, or machining. All repair welds shall be preheated and postheated as originally required, and the basic principles of the same welding procedure initially used shall be employed as far as applicable. This recognizes that the cavity to be welded may not be of the same contour or dimensions as the original joint.

228 BRAZING

228.1 Materials

228.1.1 *Filler Metal*

The filler metal used in brazing shall be a non-ferrous metal or alloy having a melting point above 800 F and below that of the metal being joined. The filler metal shall melt and flow freely within the desired temperature range and, in conjunction with a suitable flux or controlled atmosphere, shall wet and adhere to the surfaces to be joined.

228.1.2 *Flux*

Fluxes that are fluid and chemically active at the brazing temperature shall be used when necessary to prevent oxidation of the filler metal and the surfaces to be joined and to promote free flowing of the filler metal.

228.2 Preparation and Materials

228.2.1 *Surface Preparation*
The surfaces to be brazed shall be clean and free from grease, oxides, paint, scale, and dirt of any kind. Any suitable chemical or mechanical cleaning method may be used to provide a clean wettable surface for brazing.

228.2.2 *Joint Clearance*
The clearance between surfaces to be joined shall be no larger than is necessary to allow complete capillary distribution of the filler metal.

228.2.3 *Heating*
The joint shall be brought to brazing temperature in as short a time as possible to minimize oxidation without localized underheating or overheating.

228.2.4 *Brazing Qualifications*
The qualification of brazing, brazers and brazing operators shall be in accordance with the requirements of Part C, Section IX, ASME Boiler and Pressure Vessel Code.

229 BENDING

229.1 Radii of Bends

Pipe may be bent to any radius which will result in a bend free of cracks and substantially free of buckles. Out of roundness and minimum finished thickness of bend shall be such that design requirements of Subdivision 204.2 are met.

229.2 Procedure

(a) Hot bending shall be done within a temperature range consistent with material characteristics, end use, or post heat treatment.
(b) When pipe that has been cold worked (cold expanded) for the purpose of increasing its maximum yield strength is heated to 600 F or higher, the design pressure of such pipe shall not exceed 75 per cent of the value obtained under Subdivision 204.1.
(c) Bends shall be free from buckling, cracks or other evidence of mechanical damage.
(d) Bends shall not have a difference between the maximum and minimum diameters in excess of 8 per cent of the nominal diameter.

231 HEAT TREATMENT

231.1 Heating and Cooling Method

Heat treatment may be accomplished by a suitable heating method which will provide the required metal temperature, metal temperature uniformity, and temperature control. Cooling may be accomplished in a furnace, in air, with the aid of local thermal control with the application of heat or insulation, or in any other manner required to achieve the desired cooling rate.

231.2 Preheating

For low and medium carbon steels falling within material group P–1*, preheating is not required under normal conditions. When conditions exist (e.g. ambient temperatures less than 32 F), however, that either limit the welding technique that can be used or that tend to affect the quality of the weld adversely, preheating may be advisable.

231.3 Postheat Treatment (Stress Relieving)

For low and medium carbon steels falling within material group P–1*, stress relieving is not required under normal conditions provided the thickness of the steel is less than ¾ inch. When adverse conditions exist which tend to cool the weld too rapidly, or if the thickness of the steel is ¾ inch or more, suitable stress relieving techniques shall be used.

235 ASSEMBLY AND ERECTION

235.1 General

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

235.2 Proprietary Joints

Proprietary joints of unique or unusual design shall be assembled in accordance with the manufacturer's recommendations. (See Division 218)

235.4 Threaded Joints

235.4.1 *Seal Welds*
Threaded joints which are to be seal welded shall be made up without any thread compound.

235.4.2 *Joint Compound*
Any compound used in threaded joints shall be suitable for the service conditions, and shall not react adversely with the gas being conveyed in the system.

235.5 Installation of Pipe Below Ground

235.5.1 *Installation*
The ditch shall be graded so that the pipe

*All of the steel materials listed in Tables 202.3.1 fall into P–1 material group. For a more complete classification of materials by P-Number, see Appendix D of ASA B31.3.

has a firm substantially continuous bearing on the bottom of the ditch. The pipe shall fit the ditch without the use of external force to hold it in place until the backfill is completed. When long sections of pipe that have been welded alongside the ditch are lowered in, care shall be exercised so as not to jerk the pipe or impose any strains that may kink or put a permanent bend in the pipe. Slack loops are not prohibited where laying conditions render their use advisable.

Pipe shall not be sprung into a curved ditch by the use of external force and retained in position by pressure against the walls of the ditch.

235.5.2 *Backfilling*

Where flooding of the trench is done to consolidate the backfill, care shall be exercised to see that the pipe is not floated from its firm bearing on the trench bottom.

235.5.3 *Cover Requirements*

Underground piping systems should be installed with at least 18 inches of cover. The cover may be reduced to 12 inches if it appears that external damage to the pipe will not be likely to result. If, for any reason, a minimum of 12 inches of cover cannot be maintained, the pipe shall be cased or bridged (shielded).

235.5.4 *Casing Requirements*

Casings shall be designed to withstand the superimposed loads. Where there is a possibility of water entering the casing, the ends of the casing shall be sealed. If the end sealing is of a type that will retain the full pressure of the pipe, the casing shall be designed for the same pressure as the pipe. Venting of sealed casings is not mandatory; however, if vents are installed they should be protected from the weather to prevent water from entering the casing.

235.5.5 *Clearances*

There shall be at least 2 inches clearance between any gas piping system and any other underground structure not used in conjunction with the piping system. When this clearance cannot be attained, other suitable precautions to protect the pipe shall be taken, such as the installation of insulating material, installation of casing, etc.

CHAPTER VI

INSPECTION AND TEST

236 INSPECTION

236.5 Type and Extent of Inspection Required

236.5.1 All welds shall be visually examined either during or after manufacture, fabrication, assembly or test to insure compliance with the requirements in Sub-paragraph 227.4.2(d) or 227.4.3(c).

236.5.2 Supplementary types of non-destructive inspections, using magnetic-particle, radiographic, ultra-sonic or other inspection techniques, are not required unless specified by the engineering design because unusual service conditions exist which require a high degree of freedom from imperfections.

237 PRESSURE TESTS

237.1 General

Prior to acceptance and initial operation, installed piping shall be pressure tested to assure tightness.

In the event repairs or additions are made following the pressure test, the affected piping shall be retested, except that in the case of minor repairs or additions retest may be omitted when precautionary measures are taken to assure sound construction.

Because it is sometimes necessary to divide a piping system into test sections and install test heads, connecting piping, and other necessary appurtenances for testing, it is not required that the tie-in sections of pipe be pressure tested. Tie-in connections, however, shall be tested with soap suds after gas has been introduced and the pressure has been increased sufficiently to give some indications should leaks exist.

The test procedure used shall be capable of disclosing all leaks in the section being tested and shall be selected after giving due consideration to the volumetric content of the section and to its location.

A piping system may be tested as a complete unit or in sections as the construction progresses. *Under no circumstances shall a valve in a line be used as a bulkhead between gas in one section of the piping system and air or water in an adjacent section,* unless two valves are installed in series with a valved tell-tail located between these valves. A valve shall not be subjected to the test pressure unless it can be determined that the valve, including the valve closing mechanism, is designed to safely withstand the proposed test pressure.

Regulator and valve assemblies fabricated independently of the piping system in which they are to be installed, may be tested with inert gas at the time of fabrication.

237.2 Test Medium

The test medium used shall be air, water, or inert gas (e.g., nitrogen, carbon dioxide).

237.3 Test Preparation

Whenever possible, pipe joints, including welds, shall be left uncoated and exposed for examination during the test. If the pipe and joints have been previously tested in accordance with this Code, they may be insulated, covered, or concealed.

Piping shall be provided with additional temporary supports, if necessary, to support the weight of the test liquid.

Expansion joints shall be provided with temporary restraints, if required, for the additional thrust load under test.

Equipment which is not to be included in the test shall be either disconnected from the piping or isolated by blanks, blind flanges, or caps.

Flanged joints at which blinds are inserted to blank off other equipment during the test need not be tested.

If a pressure test is to be maintained for a period of time and the test liquid in the system is subject to thermal expansion, precautions shall be taken to avoid excessive pressure.

Prior to testing, the interior of the piping shall be cleared of all foreign material.

237.4 Test Pressure

The test pressure to be used shall be not less than 1½ times the maximum working pressure (but not less than 3 psig) irrespective of design temperature. If air or an inert gas is used as the test medium, the test pressure shall not exceed a value which produces a hoop stress in the piping greater than 50 per cent of the specified minimum yield strength of the pipe. Where the piping system is connected to equipment or appliances having components designed for operating pressures of less than 3 psig, such equipment or appliances shall be disconnected during the test period.

Test duration shall be long enough to determine if there are any leaks but not less than one-half hour for each 500 cubic feet of pipe volume or fraction thereof except that when testing a system having a volume less than 10 cubic feet, the test duration may be reduced to ten minutes. For piping systems having a volume of more than 24,000 cubic feet, the duration of the test need not exceed 24 hours.

237.5 Test Records

Records shall be made of each piping installation during the testing. A certification shall be made that all piping has been pressure tested as required by this Code.

237.6 Detection of Leaks and Defects

While subjected to test pressure the piping system shall be visually examined for signs of leakage or other defects. If air or inert gas is used, all exposed joints (flanged, threaded, welded, etc.) shall be checked by means of a soap bubble test or other foaming agent test. Any reduction of test pressures as indicated by pressure gages shall be deemed to indicate the presence of a leak unless such reduction can be readily attributed to some other cause.

If leakage or other defects appear, the affected portion of the piping system shall be repaired or replaced and retested.

APPENDIX A

STANDARDS AND SPECIFICATIONS INCORPORATED

APPROVED FOR USE UNDER THIS CODE

ASTM Specifications

A 47-66 T	A 338-61
A 48-64	A 350-65
A 53-67 A	A 352-66
A 72-66	A 354-66
A 105-65	A 381-66
A 106-67	A 395-66 T
A 120-66	A 414-64
A 126-66	A 420-64
A 134-64	A 445-66
A 135-66 T	B 11-66 A
A 139-64	B 26-65
A 155-66	B 42-66
A 161-66	B 43-66
A 178-66	B 61-63
A 179-66	B 62-63
A 181-65	B 68-66
A 192-66	B 75-66
A 193-66	B 88-66 A
A 197-47	B 96-66 A
A 210-65	B 111-66 A
A 211-63	B 124-66 A
A 214-66	B 132-52
A 216-66	B 143-61
A 226-66	B 147-63
A 234-65	B 148-65 T
A 245-64	B 149-52
A 254-64	B 152-66
A 278-64	B 165-61
A 283-67	B 169-66 A
A 285-66	B 171-66 A
A 299-66	B 209-67
A 300-63 T	B 210-67
A 306-64	B 234-67
A 307-67	B 241-67
A 325-66 B	B 247-67
A 333-64	B 283-66 A
A 334-65	

American Standards

A 21.11 – 1964	B 16.18A – 1967
A 21.50 – 1965	B 16.20 – 1963
A 21.52 – 1965	B 16.21 – 1962
B 1.1 – 1960	B 16.22 – 1963
B 2.1 – 1960	B 16.24 – 1962
B 16.1 – 1967	B 16.25 – 1964
B 16.3 – 1963	B 16.28 – 1964
B 16.4 – 1963	B 18.2.1 – 1966
B 16.5 – 1961	B 18.2.2 – 1966
B 16.9 – 1964	B 31.1 – 1967
B 16.10 – 1957	B 31.3 – 1966
B 16.11 – 1965	B 31.8 – 1968
B 16.14 – 1965	B 36.10 – 1959
B 16.15 – 1964	C 1 – 1965
B 16.18 – 1963	Z 21.30 – 1964

API Standards

5 L	22nd Ed., 1967
5 LX	14th Ed., 1967
6A	5th Ed., 1966
6D	11th Ed., 1964
600	5th Ed., 1961
601	2nd Ed., 1962
604	2nd Ed., 1966
1104	11th Ed., 1968

ASME Codes

ASME Boiler and Pressure Vessel Code, 1968 Ed.

AAR Specifications

AAR M-404-42

MSS Standard Practices

SP-6-1963	SP-37-1959	SP-48-1956
SP-9-1955R64	SP-44-1955	SP-51-1957
SP-25-1964	SP-45-1953	SP-58-1967

Standards and specifications of the following organizations appear in the above list:

AAR American Association of Railroads
Washington, D.C.

API American Petroleum Institute
1271 Avenue of the Americas
New York, New York 10020

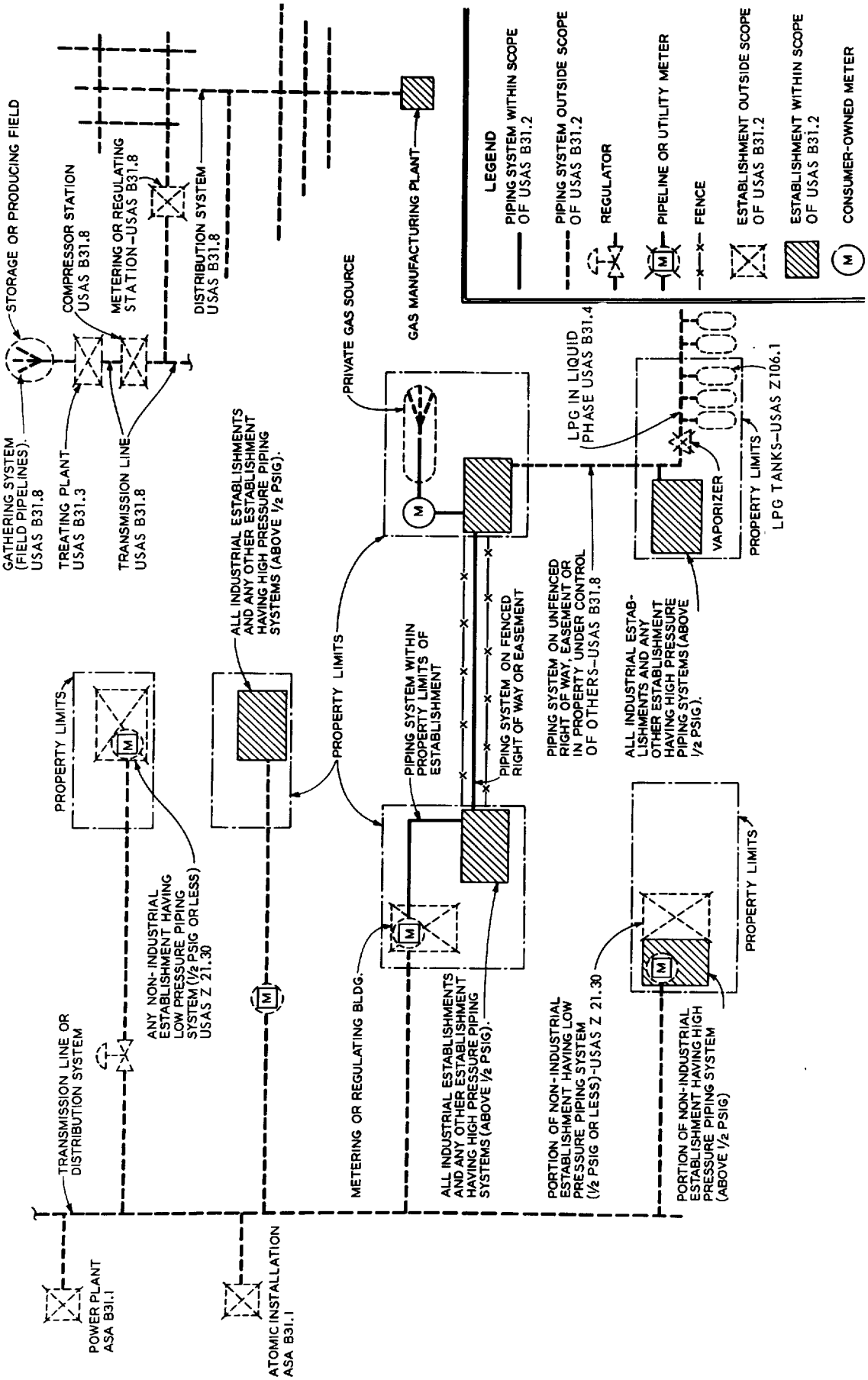
USASI United States of America Standards Institute
10 East 40th Street
New York, New York 10016

ASME American Society of Mechanical Engineers, The
345 East 47th Street
New York, New York 10017

ASTM American Society for Testing and Materials
1916 Race Street
Philadelphia, Pennsylvania 19103

MSS Manufacturers Standardization Society of the Valve and Fittings Industry
420 Lexington Avenue
New York, New York 10017

FIGURE B-1
DIAGRAM INDICATING GENERAL SCOPE OF USAS B31.2



APPENDIX C

INSTALLATION OF GAS APPLIANCES AND GAS PIPING

SCOPE OF USAS Z21.30-1964

1.1 Scope

1.1.1 *Applicability*

This standard applies to the design, fabrication, installation, tests and operation of appliance and piping systems for fuel gases such as natural gas, manufactured gas, undiluted liquefied petroleum gases, liquefied petroleum gas-air mixtures, or mixtures of any of these gases, as follows:

(a) Low pressure (not in excess of ½ pound per square inch or 14 inches water column) domestic and commercial piping systems extending from the outlet of the meter set assembly, or the outlet of the service regulator when a meter is not provided, to the inlet connections of appliances.

(b) The installation and operation of domestic and commercial appliances supplied at pressures of ½ pound per square inch or less.

APPENDIX D

TABLE 202.3.1 ALLOWABLE STRESSES FOR MATERIALS

SE values shown in this table for welded pipe include the joint factor for the longitudinal weld as required by Table 202.4.3.

For some code computations, particularly with regard to expansion, flexibility, structural attachments, supports and restraints (Part 5, Chapter II), the longitudinal joint factor E need not be considered. To determine the allowable stress (S) for use in computations not utilizing the joint factor E, divide the value shown in the table by the longitudinal joint factor E. Where no joint factor is listed, use 1.00 for E.

At those temperatures for which no stress value is listed, none have been established.

Material	Specification	Steel Making Process	Grade	Class	Tensile Strength Min psi	Yield Strength Min psi	Notes	Long. Joint Factor	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F				
									–20 to 100	200	300	400	450
CARBON STEEL, WROUGHT IRON, CAST IRON													
Seamless Carbon Steel Pipe and Tubes													
Steel Pipe	ASTM A53	OH, EF	A	Type S	48000	30000			16000	15300	14500	13800	13450
Steel Pipe	ASTM A53	OH, EF	B	Type S	60000	35000			20000	19100	18150	17250	16800
Steel Pipe	ASTM A53	DAB	B	Type S	60000	35000			20000	19100	18150	17250	16800
Steel Pipe	ASTM A106	OH, EF	A		48000	30000			16000	15300	14500	13800	13450
Steel Pipe	ASTM A106	OH, EF	B		60000	35000			20000	19100	18150	17250	16800
Steel Pipe	ASTM A106	OH, EF	C		70000	40000			23350	22250	21200	20150	19625
Steel Pipe	ASTM A120	OH, EF	A						16000	15300			
Steel Pipe	ASTM A120	OH, EF, AB	B						20000	19100			
Steel Tubes	ASTM A161	OH, EF, BO			47000	26000			15650	15000	14250	13550	13200
Steel Tubes	ASTM A179	OH, EF							15650	15000	14250	13550	13200
Steel Tubes	ASTM A192	OH, EF							15650	15000	14250	13550	13200
Steel Tubes	ASTM A210	OH, EF			60000	37000			20000	19100	18150	17250	16800
Steel Pipe	ASTM A333	OH, EF, BO	O		55000	30000			18350	17500	16700	15850	15425
Steel Tubes	ASTM A334	OH, EF, BO	O		55000	30000			18350	17500	16700	15850	15425
Steel Pipe	API 5L	OH, EF	A		48000	30000	24		16000	15300	14500	13800	13450
Steel Pipe	API 5L	OH, EF	B		60000	35000	24		20000	19100	18150	17250	16800
Steel Pipe	API 5L	DAB	B		60000	35000	24		20000	19100	18150	17250	16800
Steel Pipe	API 5LX	OH, EF	X42		60000	42000			20000	19100	18150	17250	
Steel Pipe	API 5LX	OH, EF	X46		63000	46000			21000	20050	19100	18150	
Steel Pipe	API 5LX	OH, EF	X52		66000	52000			22000	21000	20000	19000	
Steel Pipe	API 5LX	OH, EF	X52		72000	52000			23500	22500	21400	20350	

Material	Specification	Steel Making Process	Grade	Class	Tensile Strength Min psi	Yield Strength Min psi	Notes	Long. Joint Factor	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F				
									−20 to 100	200	300	400	450
CARBON STEEL, WROUGHT IRON, CAST IRON (Cont'd.)													
Carbon Steel Plates and Sheets													
Steel	ASTM A245	OH, EF	A		45000	25000	5		13800	13300	12800	12300	12000
Steel	ASTM A245	OH, EF	B		49000	30000	5		15000	14300	13650	12950	12600
Steel	ASTM A245	OH, EF	C		52000	33000	5		15950	15200	14500	13750	13400
Steel	ASTM A245	OH, EF	D		55000	40000	5		16800	16100	15500	14800	14475
Steel	ASTM A283	OH, EF	A		45000	24000	5		13800	13200	12550	11950	11650
Steel	ASTM A283	OH, EF	B		50000	27000	5		15300	14600	14000	13300	12925
Steel	ASTM A283	OH, EF	C		55000	30000	5		16900	16100	15350	14600	14200
Steel	ASTM A283	OH, EF	D		60000	33000	5		18400	17550	16750	15900	15475
Steel	ASTM A285	OH, EF	A		45000	24000			15000	14350	13650	13000	12675
Steel	ASTM A285	OH, EF	B		50000	27000			16650	15900	15200	14450	14050
Steel	ASTM A285	OH, EF	C		55000	30000			18350	17500	16700	15850	15425
Steel	ASTM A300	OH, EF		1	55000	30000			18350	17500	16700	15850	15425
Steel	ASTM A300	OH, EF		1	60000	32000			20000	19100	18150	17250	16800
Steel	ASTM A300	OH, EF		1	65000	35000			21650	20700	19700	18700	18225
Steel	ASTM A300	OH, EF		1	70000	38000			23350	22250	21200	20150	19625
Steel	ASTM A414	OH, EF	A		45000	24000			15000	14350	13650	13000	12675
Steel	ASTM A414	OH, EF	B		50000	27000			16650	15900	15200	14450	14050
Steel	ASTM A414	OH, EF	C		55000	30000			18350	17500	16700	15850	15425
Carbon Steel Forging & Seamless Fittings													
Steel	ASTM A105	OH, EF	1		60000	30000	9		18750	18100	17400	16700	16350
Steel	ASTM A105	OH, EF	11		70000	36000	9		22500	21600	20700	19750	19300
Steel	ASTM A181	OH, EF	1		60000	30000	9		18750	18100	17400	16700	16350
Steel	ASTM A181	OH, EF	11		70000	36000	9		22500	21600	20700	19750	19300
Steel	ASTM A234	OH, EF	WPA		48000	30000	13		16000	15300	14500	13800	13450
Steel	ASTM A234	OH, EF	WPB		60000	35000	13		20000	19100	18150	17250	16800
Steel	ASTM A234	OH, EF	WPC		70000	40000	13		23350	22250	21200	20150	19625
Steel	ASTM A350	OH, EF	LF 1		60000	30000	9		18750	18100	17400	16700	16350

Notes:

5. A quality factor of 92 per cent is included for structural grade.
9. Pressure temperature ratings of cast and forged parts as published in standards referenced in this Code section may be used for parts meeting requirements of these standards. Allowable stresses for castings and forgings, where listed, are for use in design for special components not furnished in accordance with such standards.
13. Stresses shown are for the lowest strength base material permitted by the specification to be used in the manufacture of this grade of fitting. If a higher strength base material is used, the higher allowable stresses for that material may be used in design.
24. *S* values above 400 F apply only to non-expanded pipe. No value is assigned to cold expanded pipe over 400 F.

TABLE 202.3.1 ALLOWABLE STRESSES FOR MATERIALS (CONT'D.)

Material	Specification	Steel Making Process	Grade	Class	Tensile Strength Min psi	Yield Strength Min psi	Notes	Long. Joint Factor	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F				
									–20 to 100	200	300	400	450
CARBON STEEL, WROUGHT IRON, CAST IRON (Cont'd.)													
Carbon Steel and Iron Castings													
Malleable Iron	ASTM A47		32510		50000	32500	9		10000	10000	10000	10000	10000
Malleable Iron	ASTM A47		35018		53000	35000	9		10600	10600	10600	10600	10600
Cast Iron	ASTM A48		20		20000				2000	2000	2000	2000	2000
Cast Iron	ASTM A48		25		25000		9		2500	2500	2500	2500	2500
Cast Iron	ASTM A48		30		30000		9		3000	3000	3000	3000	3000
Cast Iron	ASTM A48		35		35000		9		3500	3500	3500	3500	3500
Cast Iron	ASTM A48		40		40000		9		4000	4000	4000	4000	4000
Cast Iron	ASTM A48		45		45000		9		4500	4500	4500	4500	4500
Cast Iron	ASTM A48		50		50000		9		5000	5000	5000	5000	5000
Cast Iron	ASTM A48		60		60000		9		6000	6000	6000	6000	6000
Cast Iron	ASTM A126		A		21000		9		2000	2000	2000	2000	2000
Cast Iron	ASTM A126		B		31000		9		3000	3000	3000	3000	3000
Cast Iron	ASTM A126		C		41000		9		4000	4000	4000	4000	4000
Malleable Iron	ASTM A197				40000	30000	9		8000	8000	8000	8000	8000
Steel	ASTM A216	OH, EF	WCA		60000	30000	9, 22		15000	14500	13900	13350	13075
Steel	ASTM A216	OH, EF	WCB		70000	36000	9, 22		18000	17300	16550	15800	15450
Cast Iron	ASTM A278		20		20000		9		2000	2000	2000	2000	2000
Cast Iron	ASTM A278		25		25000		9		2500	2500	2500	2500	2500
Cast Iron	ASTM A278		30		30000		9		3000	3000	3000	3000	3000
Cast Iron	ASTM A278		35		35000		9		3500	3500	3500	3500	3500
Cast Iron	ASTM A278		40		40000		9		4000	4000	4000	4000	4000
Cast Iron	ASTM A278		50		50000		9		5000	5000	5000	5000	5000
Cast Iron	ASTM A278		60		60000		9		6000	6000	6000	6000	6000
Malleable Iron	ASTM A338						9		10000	10000	10000	10000	10000
Carbon Steel	ASTM A352	OH, EF	LCB		65000	35000	9, 22		17300	16550	15750	14950	14575
Nodular Iron	ASTM A395				60000	45000	9, 22		9600	9600	9600	9600	9600
Nodular Iron	ASTM A445				60000	45000	9, 22		9600	9600	9600	9600	9600
CARBON STEEL AND WROUGHT IRON PIPE AND TUBES													
Furnace Welded – Butt Welded Pipe													
Steel Pipe	ASTM A53	OH, EF		Type F	45000	25000		0.60	9000	8600	8200	7800	
Steel Pipe	ASTM A53	AB		Type F	50000	30000		0.60	10000	9550	9100	8650	
Wrought Iron Pipe	ASTM A72				40000	25000		0.60	8000	7650	7250	6900	
Steel Pipe	ASTM A120	OH, EF						0.60	9000	8600			
Steel Pipe	ASTM A120	AB						0.60	10000	9550			

Material	Specification	Steel Making Process	Grade	Class	Tensile Strength Min psi	Yield Strength Min psi	Notes	Long. Joint Factor	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F				
									–20 to 100	200	300	400	450
CARBON STEEL AND WROUGHT IRON PIPE AND TUBES (Cont'd.)													
Furnace Welded – Butt Welded Pipe (Cont'd.)													
Steel Pipe	API 5L	OH, EF		1	45000	25000		0.60	9000	8600	8200	7800	
Steel Pipe	API 5L	OH, EF		11	48000	28000		0.60	9600	9200	8700	8300	
Steel Pipe	API 5L	AB			50000	30000		0.60	10000	9550	9100	8650	
Furnace Welded – Lap Welded Pipe													
Wrought Iron Pipe	ASTM A72				40000	25000		0.75	10650	10200	9700	9200	8975
Steel Pipe	ASTM A120	OH, EF						0.75	11250	10800			
Electric Resistance Welded and Electric Flash Welded Pipe and Tubes													
Steel Pipe	ASTM A53	OH, EF	A	Type E	48000	30000		0.85	13600	13000	12300	11750	11425
Steel Pipe	ASTM A53	OH, EF	B	Type E	60000	35000		0.85	17000	16200	15400	14650	14275
Steel Pipe	ASTM A120	OH, EF	A					0.85	13600	13000			
Steel Pipe	ASTM A120	OH, EF, AB	B					0.85	17000	16200			
Steel Pipe	ASTM A135	OH, EF	A		48000	30000		0.85	13600	13000	12300	11750	11425
Steel Pipe	ASTM A135	OH, EF	B		60000	35000		0.85	17000	16200	15400	14650	14275
Steel Tubes	ASTM A178	OH, EF	A					0.85	13300	12750	12150	11500	11200
Steel Tubes	ASTM A178	OH, EF	C		60000	37000		0.85	17000	16200	15400	14650	14275
Steel Tubes	ASTM A214	OH, EF						0.85	13300	12750	12150	11500	11200
Steel Tubes	ASTM A226	OH, EF, BO						0.85	13300	12750	12150	11500	11200
Steel Pipe	ASTM A333	OH, EF, BO	O		55000	30000		0.85	15600	14850	14150	13450	13100
Steel Tubes	ASTM A334	OH, EF, BO	O		55000	30000		0.85	15600	14850	14150	13450	13100
Steel Pipe	API 5L	OH, EF	A		48000	30000		0.85	13600	13000	12300	11750	11425
Steel Pipe	API 5L	OH, EF	B		60000	35000		0.85	17000	16200	15400	14650	14275
Steel Pipe	API 5LX	OH, EF	X42		60000	42000		0.85	17000	16200	15400	14650	
Steel Pipe	API 5LX	OH, EF	X46		63000	46000		0.85	17850	17000	16200	15400	
Steel Pipe	API 5LX	OH, EF	X52		66000	52000		0.85	18700	17850	17000	16100	
Steel Pipe	API 5LX	OH, EF	X52		72000	52000		0.85	20000	19100	18200	17300	

9. Pressure temperature ratings of cast and forged parts as published in standards referenced in this Code may be used for parts meeting requirements of these standards. Allowable stresses for castings and forgings, where listed, are for use in design for special components not furnished in accordance with such standards.
22. Stress values shown include a casting quality factor of 0.80. Higher factors may be used if special inspection is accomplished as prescribed in Par. 302.3.1 of USAS B31.3.

TABLE 202.3.1 ALLOWABLE STRESSES FOR MATERIALS (CONT'D.)

Material	Specification	Steel Making Process	Grade	Class	Tensile Strength Min psi	Yield Strength Min psi	Notes	Long. Joint Factor	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F				
									–20 to 100	200	300	400	450
CARBON STEEL AND WROUGHT IRON PIPE AND TUBES (Cont'd.)													
Electric Fusion Welded Pipe (Straight Seam)													
A 245, GR.A	ASTM A134	OH, EF			45000	25000		0.80	11050	10550	10050		
A 245, GR.B	ASTM A134	OH, EF			49000	30000		0.80	12000	11450	10900		
A 245, GR.C	ASTM A134	OH, EF			52000	33000		0.80	12750	12150	11600		
A 245, GR.D	ASTM A134	OH, EF			55000	40000		0.80	13500	12850	12250		
A 283, GR.A	ASTM A134	OH, EF			45000	24000		0.80	11050	10550	10050		
A 283, GR.B	ASTM A134	OH, EF			50000	27000		0.80	12250	11650	11200		
A 283, GR.C	ASTM A134	OH, EF			55000	30000		0.80	13500	12900	12300		
A 283, GR.D	ASTM A134	OH, EF			60000	33000		0.80	14750	14000	13400		
A 285, GR.A	ASTM A134	OH, EF			45000	24000		0.80	12000	11500	10900		
A 285, GR.B	ASTM A134	OH, EF			50000	27000		0.80	13300	12700	12200		
A 285, GR.C	ASTM A134	OH, EF			55000	30000		0.80	14700	14000	13300		
Steel Pipe	ASTM A139	OH, EF	A		48000	30000		0.80	12800	12300	11700		
Steel Pipe	ASTM A139	OH, EF	B		60000	35000		0.80	16000	15350	14600		
A 285, GR.A	ASTM A155	OH, EF	C45	2	45000	24000		0.85	12750	12200	11600	11050	
A 285, GR.B	ASTM A155	OH, EF	C50	2	50000	27000		0.85	14150	13500	12900	12300	
A 285, GR.C	ASTM A155	OH, EF	C55	2	55000	30000		0.85	15600	14900	14200	13500	13125
A 201, GR.A	ASTM A155	OH, EF	KC55	2	55000	30000		0.85	15600	14900	14200	13500	13125
A 201, GR.B	ASTM A155	OH, EF	KC60	2	60000	32000		0.85	17000	16250	15450	14650	14275
A 212, GR.A	ASTM A155	OH, EF	KC65	2	65000	35000		0.85	18400	17600	16750	15900	15500
A 212, GR.B	ASTM A155	OH, EF	KC70	2	70000	38000		0.85	19850	18900	18000	17150	16700
A 285, GR.A	ASTM A155	OH, EF	C45	2	45000	24000	17	0.90	13500	12900	12300	11700	11400
A 285, GR.B	ASTM A155	OH, EF	C50	2	50000	27000	17	0.90	15000	14300	13700	13000	12650
A 285, GR.C	ASTM A155	OH, EF	C55	2	55000	30000	17	0.90	16500	15750	15000	14250	13875
A 201, GR.A	ASTM A155	OH, EF	KC55	2	55000	30000	17	0.90	16500	15750	15000	14250	13875
A 201, GR.B	ASTM A155	OH, EF	KC60	2	60000	32000	17	0.90	18000	17200	16350	15500	15100
A 212, GR.A	ASTM A155	OH, EF	KC65	2	65000	35000	17	0.90	19500	18650	17750	16350	16150
A 212, GR.B	ASTM A155	OH, EF	KC70	2	70000	38000	17	0.90	21000	20000	19100	18150	17675
A 285, GR.A	ASTM A155	OH, EF	C45	1	45000	24000		1.00	15000	14350	13650	13000	12675
A 285, GR.B	ASTM A155	OH, EF	C50	1	50000	27000		1.00	16650	15900	15200	14450	14050
A 285, GR.C	ASTM A155	OH, EF	C55	1	55000	30000		1.00	18350	17500	16700	15850	15425
A 201, GR.A	ASTM A155	OH, EF	KC55	1	55000	30000		1.00	18350	17500	16700	15850	15425
A 201, GR.B	ASTM A155	OH, EF	KC60	1	60000	32000		1.00	20000	19100	18150	17250	16800
A 212, GR.A	ASTM A155	OH, EF	KC65	1	65000	35000		1.00	21650	20700	19700	18700	18225
A 212, GR.B	ASTM A155	OH, EF	KC70	1	70000	38000		1.00	23350	22250	21200	20150	19625
Steel Pipe	ASTM A381		Y35		60000	35000	19	0.85	17000	16250	15450	14650	14275

Material	Specification	Steel Making Process	Grade	Class	Tensile Strength Min psi	Yield Strength Min psi	Notes	Long. Joint Factor	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F				
									–20 to 100	200	300	400	450
CARBON STEEL AND WROUGHT IRON PIPE AND TUBES (Cont'd.)													
Electric Fusion Welded Pipe (Straight Seam) (Cont'd.)													
Steel Pipe	ASTM A381		Y42		68000	42000	19	0.85	19250	18400	17500	16750	16250
Steel Pipe	ASTM A381		Y46		70000	46000	19	0.85	19850	18900	18000	17150	16700
Steel Pipe	ASTM A381		Y48		72000	48000	19	0.85	20400	19450	18550	17650	17175
Steel Pipe	ASTM A381		Y50		72000	50000	19	0.85	20400	19500	18700	17800	17400
Steel Pipe	ASTM A381		Y52		75000	52000	19	0.85	21200	20400	19300	18400	17900
Steel Pipe	ASTM A381		Y35		60000	35000	19	0.90	18000	17200	16350	15550	15125
Steel Pipe	ASTM A381		Y42		68000	42000	19	0.90	20500	19500	18600	17750	17225
Steel Pipe	ASTM A381		Y46		70000	46000	19	0.90	21000	20000	19100	18200	17700
Steel Pipe	ASTM A381		Y48		72000	48000	19	0.90	21600	20600	19650	18700	18225
Steel Pipe	ASTM A381		Y50		72000	50000	19	0.90	21600	20700	19800	18900	18450
Steel Pipe	ASTM A381		Y52		75000	52000	19	0.90	22500	21500	20500	19500	18950
Steel Pipe	ASTM A381		Y35		60000	35000		1.00	20000	19100	18150	17250	16800
Steel Pipe	ASTM A381		Y42		68000	42000		1.00	22650	21650	20600	19700	19125
Steel Pipe	ASTM A381		Y46		70000	46000		1.00	23350	22250	21200	20150	19625
Steel Pipe	ASTM A381		Y48		72000	48000		1.00	24000	22900	21800	20750	20200
Steel Pipe	ASTM A381		Y50		72000	50000		1.00	24000	23000	22000	21000	20500
Steel Pipe	ASTM A381		Y52		75000	52000		1.00	25000	24000	22800	21700	21100
Steel Pipe	API 5LX	OH, EF	X42		60000	42000		0.85	17000	16200	15400	14650	
Steel Pipe	API 5LX	OH, EF	X46		63000	46000		0.85	17900	17450	16200	15400	
Steel Pipe	API 5LX	OH, EF	X52		66000	52000		0.85	18700	17900	17000	16100	
Steel Pipe	API 5LX	OH, EF	X52		72000	52000		0.85	20400	19100	18200	17300	
Spiral Welded Pipe													
A 245, GR.A	ASTM A134	OH, EF			45000	25000	5	0.80	11050	10650			
A 245, GR.B	ASTM A134	OH, EF			49000	30000	5	0.80	11750	11400			
A 245, GR.C	ASTM A134	OH, EF			52000	33000	5	0.80	12700	12250			
A 245, GR.D	ASTM A134	OH, EF			55000	40000	5	0.80	13450	12800			
A 283, GR.A	ASTM A134	OH, EF			45000	24000	5	0.80	11050	10550			
A 283, GR.B	ASTM A134	OH, EF			50000	27000	5	0.80	12200	11850			
A 283, GR.C	ASTM A134	OH, EF			55000	30000	5	0.80	13450	12900			
A 283, GR.D	ASTM A134	OH, EF			60000	33000	5	0.80	14700	14050			
A 285, GR.A	ASTM A134	OH, EF			45000	24000		0.80	12000	11500			
A 285, GR.B	ASTM A134	OH, EF			50000	27000		0.80	13300	11650			

5. A quality factor of 92 per cent is included for structural grade.
17. These specifications do not include requirements or rules for random radiographic inspection. If this higher joint factor is to be used, material shall be purchased to the special requirements of Par. 227.4.3 with random radiography in accordance with Table 202.4.3; and the user must take appropriate steps to insure thar required inspection and repair is accomplished.
19. These specifications include requirements for random radiographic inspection for mill quality control. If the 0.90 joint factor is to be used, this inspection must meet the special requirements of Par. 227.4.3 with random radiography in accordance with Table 202.4.3. This shall be a matter of special agreement between purchaser and manufacturer.

TABLE 202.3.1 ALLOWABLE STRESSES FOR MATERIALS (CONT'D.)

Material	Specification	Steel Making Process	Grade	Class	Tensile Strength Min psi	Yield Strength Min psi	Notes	Long. Joint Factor	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F				
									–20 to 100	200	300	400	450
CARBON STEEL AND WROUGHT IRON PIPE AND TUBES (Cont'd.)													
Spiral Welded Pipe (Cont'd.)													
A 285, GR.C Steel Pipe	ASTM A134	OH, EF			55000	30000		0.80	14650	14050			
Steel Pipe	ASTM A139	OH, EF	A		48000	30000		0.80	12800	12300			
Steel Pipe	ASTM A139	OH, EF	B		60000	35000		0.80	16000	15350			
Steel Pipe	ASTM A211	OH, EF	A245 GR.A		45000	25000	5	0.75	10300	10000			
Steel Pipe	ASTM A211	OH, EF	A245 GR.B		49000	30000	5	0.75	11000	10700			
Steel Pipe	ASTM A211	OH, EF	A245 GR.C		52000	33000	5	0.75	11900	11500			
Steel Pipe	ASTM A211	OH, EF	A245 GR.D		55000	40000	5	0.75	12600	12050			
Wrought Iron Pipe	ASTM A211	OH, EF	A129 GR.A		40000	22000		0.75	10650	10200			
Wrought Iron Pipe	ASTM A211	OH, EF	A129 GR.B		44000	27000		0.75	11750	11200			
Wrought Iron Pipe	ASTM A211	OH, EF	A129 GR.C		42000	23000		0.75	11200	10700			
Copper Brazed Tubes													
Steel	ASTM A254	OH, EF		1	42000	28000			6000	5500	4750	3000	
Steel	ASTM A254	OH, EF		11	42000	28000			3600	3300	2850	1800	

5. A quality factor of 92 per cent is included for structural grade.

Material	Specification	Grade	Class	Size Range	Tensile Strength Min psi	Yield Strength Min psi	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F							
							Notes	–20 to 100	150	200	250	300	350	400	450
COPPER AND COPPER ALLOYS															
Copper and Copper Alloy Seamless Pipe and Tubes															
Copper Pipe	ASTM B42	Annealed		1/8" – 2" Incl. 2½" – 12" Incl.	30000	9000	8	6000	6000	5900	5800	5000	3800	2500	1500
Copper Pipe	ASTM B42	Hard Drawn			45000	40000	8	11300	11300	11000	10500	8000	5000	2500	1500
Copper Pipe	ASTM B42	Light Drawn			36000	30000	8	9000	9000	8700	8300	8000	5000	2500	1500
Red Brass Pipe	ASTM B43	Annealed			40000	12000	8	8000	8000	8000	8000	8000	6000	3000	2000
Copper Tube	ASTM B68	Annealed			30000			6000	6000	5900	5800	5000	3800	2500	1500
Copper Tube	ASTM B75	Annealed			30000	9000	8	6000	6000	5900	5800	5000	3800	2500	1500
Copper Tube	ASTM B75	Light Drawn			36000	30000	8	9000	9000	8700	8300	8000	5000	2500	1500
Copper Tube	ASTM B75	Hard Drawn			45000	40000	8	11300	11300	11000	10500	8000	5000	2500	1500
Copper Tube	ASTM B88	Annealed			30000			6000	6000	5900	5800	5000	3800	2500	1500
Copper Tube	ASTM B88	Drawn			36000			9000	9000	8700	8300	8000	5000	2500	1500
Copper Tube	ASTM B111	Light Drawn	Types A–D		36000	30000	8	9000	9000	8700	8300	8000	5000	2500	1500
Copper Tube	ASTM B111	Hard Drawn			45000	40000	8	11300	11300	11000	10500	8000	5000	2500	1500
Muntz Tube	ASTM B111	Annealed			50000	20000	8	12500	12500	12000	11200	10500	7500	2000	
Admiralty Tube	ASTM B111	Annealed			45000	15000	8	10000	10000	10000	10000	10000	8000	5000	3000
Red Brass Tube	ASTM B111	Annealed			40000	12000	8	8000	8000	8000	8000	8000	6000	3000	2000
Aluminum Brass Tube	ASTM B111	Annealed	Types B–D		50000	18000	8	12000	12000	12000	12000	12000	7500	3000	2000
Aluminum Bronze Tube	ASTM B111	Annealed			50000	19000	8	12500	12400	12200	11900	11600	10000	6000	4000
70-30 Copper Nickel Tube	ASTM B111	Annealed			52000	18000	8	12000	11600	11300	11000	10800	10600	10300	10100

8. For use in code piping at the stated allowable stresses, the required tensile properties must be verified by tensile test at the mill; such tests shall be specified in the purchase order.

TABLE 202.3.1 ALLOWABLE STRESSES FOR MATERIALS (CONT'D.)

Material	Specification	Grade	Class	Size Range	Tensile Strength Min psi	Yield Strength Min psi	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F							
							Notes	–20 to 100	150	200	250	300	350	400	450
COPPER AND COPPER ALLOYS (Cont'd.)															
Copper and Copper Alloys Seamless Pipe and Tubes (Cont'd.)															
80-20 Copper Nickel Tube	ASTM B111	Annealed			45000	16000	8	10700	10600	10500	10400	10300	10100	9900	9600
90-10 Copper Nickel Tube	ASTM B111	Annealed			40000	15000	8	10000	10000	9800	9500	9300	9000	8700	8300
Copper and Copper Alloy Plates and Sheets															
Copper	ASTM B11	ETP, FRTP DHP			30000	10000	8, 10	6700	6700	6500	6300	5000	3800	2500	1500
Arsenical Copper	ASTM B11	ATP, DPA			31000	10000	8, 10	6700	6700	6500	6300	5000	3800	2500	1500
Copper-Silicon	ASTM B96	A,C			50000	18000		12000	12000	11900	11700	10000	5000		
Copper	ASTM B152	Annealed			30000			6700	6700	6500	6300	5000	3800	2500	1500
Aluminum Bronze	ASTM B169	D			70000	30000	11	17500	17500	16800	16000	15500	15000	14000	12000
Leaded Muntz	ASTM B171				50000	20000	11	12500	12500	12000	11200	10500	7500	2000	750
Naval Brass	ASTM B171				50000	20000	11	12500	12500	12000	11200	10500	7500	2000	750
Admiralty Brass	ASTM B171	A–D			45000	15000	11	10000	10000	10000	10000	10000	8000	5000	3000
70-30 Copper Nickel	ASTM B171				50000	20000	11	12500	12500	12500	12500	12200	12000	11700	11300
90-10 Copper Nickel	ASTM B171				40000	15000	11	10000	10000	9800	9500	9300	9000	8700	8300
Aluminum Bronze	ASTM B171	D			70000	30000	11	17500	17500	16800	16000	15500	15000	14500	12000
Aluminum Bronze	ASTM B171	E			90000	36000	11	22500	22500	21000	19500	18000	16500	15000	13500
Copper and Copper Alloy Forgings															
Aluminum Bronze	ASTM B124	11B	E				8, 9	22500	21800	21000	19750	18000	16750	15000	13500
Forging Brass	ASTM B283				58000	23000	8, 9	12500	12500	12000	11200	10500	7500	2000	
Naval Brass	ASTM B283				64000	26000	8, 9	16000	15750	15350	14250	13000	9000	2000	

Material	Specification	Grade	Class	Size Range	Tensile Strength Min psi	Yield Strength Min psi	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F								
							Notes	–20 to 100	150	200	250	300	350	400	450
COPPER AND COPPER ALLOYS (Cont'd.)															
Copper and Copper Alloy Forgings (Cont'd.)															
Leaded Naval Brass	ASTM B283				62000	24000	8,9	15500	15250	15000	14100	13000	8500	2000	
Manganese Bronze	ASTM B283		A		72000	34000	8,9	13750	12900	12000	11200	10500	7500	2000	
Aluminum-Silicon Bronze	ASTM B283				83000	41000	8,9	17500	17500	17300	17100	17100	17000	16800	
Copper	ASTM B283				33000	11000	8,9	6700	6700	6500	6300	5000	3800	2500	1500
High-Silicon Bronze	ASTM B283		A		52000	18000	8,9	10000	10000	10000	10000	10000	5000	2000	
Copper and Copper Alloy Castings															
Steam Bronze	ASTM B61				34000	16000	9	6800	6700	6650	6550	6450	6300	6050	5750
Composition Brass	ASTM B62				30000	14000	9	6000	5800	5650	5500	5400	5250	5200	3450
Manganese Bronze	ASTM B132	A			60000	20000	9	10650	10150	9600	9000	8400	6000		
Manganese Bronze	ASTM B132	B			80000	32000	9	16000	14000	12200	10300	8400	6000		
Tin Bronze	ASTM B143	1A			40000	18000	9	8000	8000	7600	7400	6800	6400	5600	
Tin Bronze	ASTM B143	1B			40000	18000	9	8000	8000	7600	7400	6800	6400	5600	
Leaded Tin Bronze	ASTM B143	2A			34000	16000	9	6800	6800	6800	6800	6800	6400	5600	
Leaded Tin Bronze	ASTM B143	2B			36000	16000	9	7200	7200	7200	7200	6800	6400	5600	
Leaded Mn Bronze	ASTM B147	7A			60000	20000	9	10600	10200	9600	8950	8400	6000		
Mn Bronze	ASTM B147	8A			65000	25000	9	13000	11800	10700	9600	8400	6000		
Mn Bronze	ASTM B147	8B			90000	45000	9	18000	15600	13800	13200	8400	6000		
Mn Bronze	ASTM B147	8C			110000	60000	9	22000	18600	15200	11800	8400	6000		
Aluminum Bronze	ASTM B148	9A			65000	25000	9	13000	13000	12900	12800	12400	12000	11600	9600

8. For use in code piping at the stated allowable stresses, the required tensile properties must be verified by tensile test at the mill; such tests shall be specified in the purchase order.
9. Pressure temperature ratings of cast and forged parts as published in standards referenced in this Code may be used for parts meeting requirements of these standards. Allowable stresses for castings and forgings, where listed, are for use in design for special components not furnished in accordance with such standards.
10. Material for use in code piping bought to these specifications shall have a minimum yield strength of 10,000 psi at 0.5 per cent extension under load.
11. Properties of this material vary with thickness or size. Stresses are based on minimum properties.

TABLE 202.3.1 ALLOWABLE STRESSES FOR MATERIALS (CONT'D.)

Material	Specification	Grade	Class	Size Range	Tensile Strength Min psi	Yield Strength Min psi	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F								
							Notes	–20 to 100	150	200	250	300	350	400	450
COPPER AND COPPER ALLOYS (Cont'd.)															
Copper and Copper Alloy Castings (Cont'd.)															
Aluminum Bronze	ASTM B148	9B			65000	25000	9	13000	13000	12900	12800	12400	12000	11600	9600
Aluminum Bronze	ASTM B148	9C			75000	30000	9	15000	15000	14400	13750	13000	12500	11800	10300
Aluminum Bronze	ASTM B148	9D			90000	40000	9	18000	18000	16800	15600	14400	13200	12000	10800
Leaded Nickel Brass	ASTM B149	10A			30000	15000	9	6000							
Leaded Nickel Bronze	ASTM B149	11A			30000	17000	9	6000	6000	6000	6000	6000	5600		
Leaded Nickel Bronze	ASTM B149	11B			45000	22000	9	9000	8300	7500	6750	6000	5600		

9. Pressure temperature ratings of cast and forged parts as published in standards referenced in this Code may be used for parts meetings requirements of these standards. Allowable stresses for castings and forgings, where listed, are for use in design for special components not furnished in accordance with such standards.

Specification	Grade	Temper	Tensile Strength Min psi	Yield Strength Min psi	Notes	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F						
						–20 to 100	150	200	250	300	350	400
ALUMINUM AND ALUMINUM BASE ALLOYS												
Aluminum and Aluminum Base Alloys Seamless Pipe and Tubes												
ASTM B210	1060	O	9500	2500	8	1650	1650	1600	1450	1250	1200	1050
		H112	10000	4000	8,15	2500	2150	1950	1700	1500	1300	1100
ASTM B210 ASTM B234	1060	H14	12000	10000	8,15	3000	3000	2900	2700	2350	2000	1600
ASTM B210	3003	O	14000	5000	8,15	3350	3150	2900	2700	2400	2100	1800
ASTM B210 ASTM B234	3003	H14	20000	17000	8,15	5000	4850	4700	4400	4000	3500	3100
ASTM B210 ASTM B241	3003	H18	27000	24000	8,15	6750	6400	6050	5700	5250	4400	3500
ASTM B241	3003	H112	14500	6000	8,15	3600	3250	3000	2800	2500	2200	1900
ASTM B210	3003 Clad	O	13000	4500	8,15	3000	2900	2700	2500	2200	1950	1700
ASTM B210 ASTM B234	3003 Clad	H14	19000	16000	8,15	4750	4600	4450	4200	3800	3350	2900
ASTM B210	3003 Clad	H18	26000	23000	8,15	6500	6100	5800	5500	5050	4200	3350
ASTM B210	5050	O	18000	6000	8	4000	4000	4000	4000	4000	3350	2100
ASTM B210	5052	O	25000	10000	8	6250	6250	6200	6000	5400	4650	3500
ASTM B210	5154	O	30000	11000	8	7350	7350	7350	7000	6200	5500	2600
ASTM B210	5154	H34	39000	29000	8,15	9750	9700	9500	8800	7900	5500	2600
ASTM B210 ASTM B234	6061	T4	26000	16000	8,15	6500	6200	6000	5800	5600	4900	3500
ASTM B210 ASTM B234 ASTM B241	6061	T6	38000	35000	8,15	9500	9200	9000	8500	7200	5600	4000
ASTM B210	6063	T4	22000	10000	8,15	5500	5100	4900	4600	4150	3100	2000
ASTM B210 ASTM B241	6063	T6	30000	25000	8,15	7500	7100	6800	6100	4500	3100	2000

8. For use in code piping at the stated allowable stresses, the required tensile properties must be verified by tensile test at the mill; such tests shall be specified in the purchase order.

15. For welded construction with work hardened grades, use the stresses for annealed material; for welded construction with precipitation hardened grades, use the special allowable stresses for welded construction given in the Tables.

TABLE 202.3.1 ALLOWABLE STRESSES FOR MATERIALS (CONT'D.)

Specification	Grade	Temper	Tensile Strength Min psi	Yield Strength Min psi	Notes	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F						
						−20 to 100	150	200	250	300	350	400
ALUMINUM AND ALUMINUM BASE ALLOYS (Cont'd.)												
Aluminum and Aluminum Base Alloy Forgings												
ASTM B247	6061	T6	38000	35000	9,11,15	9500	9200	9000	8500	7200	5600	4000
Aluminum and Aluminum Base Alloy Castings												
ASTM B26	S5A	F	17000	6000	8,9,27	4000	4000	3700	3400	3100	2850	2550
ASTM B26	SG70A	T6	30000	20000	8,9,27	7500	7400	6900	5700			
		T71	25000	18000	8,9,27	6250	6000	5750	5500	4950	3750	2600
Aluminum and Aluminum Base Alloy Sheet and Plate												
ASTM B209	1060	O	9500	2500	8	1650	1650	1600	1450	1250	1200	1050
		H112	10000	4000	8,11,15	2500	2150	1950	1700	1500	1300	1100
		H12	11000	9000	8,15	2750	2550	2350	2100	1900	1600	1400
		H14	12000	11000	8,15	3000	3000	2900	2700	2350	2000	1600
ASTM B209	1100	O	11000	3500	8	2350	2350	2300	2100	1850	1600	1300
		H112	12000	5000	8,11,15	3000	2800	2550	2250	2000	1700	1400
		H12	14000	11000	8,15	3500	3400	3150	2900	2650	2400	1700
		H14	16000	14000	8,15	4000	3900	3650	3300	3000	2700	1700
ASTM B209	3003	O	14000	5000	8	3350	3150	2900	2700	2400	2100	1800
		H112	14500	6000	8,11,15	3600	3250	3000	2800	2500	2200	1900
		H12	17000	12000	8,15	4250	4000	3800	3600	3300	3000	2650
		H14	20000	17000	8,15	5000	4850	4700	4400	4000	3500	3150
ASTM B209	3003 Clad	O	13000	4500	8	3000	2900	2700	2500	2200	1950	1700
		H112	14500	6000	8,11,15	3600	3200	3000	2800	2500	2200	1900
		H12	16000	11000	8,15	4000	3800	3600	3400	3100	2800	2500
		H14	19000	16000	8,15	4750	4600	4450	4200	3800	3350	2900
ASTM B209	3004	O	22000	8500	8	5500	5500	5500	5200	4550	3600	2950
		H112	23000	9000	8,11,15	5750	5750	5750	5500	4650	3850	3150
		H32	28000	21000	8,15	7000	7000	7000	6550	5800	5050	3500
		H34	32000	25000	8,15	8000	8000	8000	7400	6550	5600	3500
ASTM B209	3004 Clad	O	21000	8000	8	5250	5250	5200	5000	4350	3450	2800
		H112	22000	8500	8,11,15	5500	5500	5500	5200	4550	3600	2950
		H32	27000	20000	8,15	6800	6800	6800	6300	5600	4900	3400
		H34	31000	24000	8,15	7800	7800	7700	7200	6300	5400	3400

8. For use in code piping at the stated allowable stresses, the required tensile properties must be verified by tensile test at the mill; such tests shall be specified in the purchase order.
9. Pressure temperature ratings of cast and forged parts as published in standards referenced in this Code may be used for parts meeting requirements of these standards. Allowable stresses for castings and forgings, where listed, are for use in design for special components not furnished in accordance with such standards.
11. Properties of this material vary with thickness or size. Stresses are based on minimum properties.
15. For welded construction with work hardened grades, use the stresses for annealed material; for welded construction with precipitation hardened grades, use the special allowable stresses for welded construction given in the Tables.
27. Cast aluminum alloys shall not be welded.

Specification	Grade	Temper	Tensile Strength Min psi	Yield Strength Min psi	Notes	ALLOWABLE STRESS (psi) Metal Temperature – Degrees F						
						–20 to 100	150	200	250	300	350	400
ALUMINUM AND ALUMINUM BASE ALLOYS (Cont'd.) Aluminum and Aluminum Base Alloy Sheet and Plate (Cont'd.)												
ASTM B209	5050	O	18000	6000	8	4000	4000	4000	4000	4000	3350	2100
		H112	20000	8000	8,11,15	5000	5000	5000	4900	4500	3700	2100
		H32	22000	16000	8,15	5500	5500	5500	5350	4800	3800	2100
		H34	25000	20000	8,15	6250	6200	6200	6050	5400	3950	2100
ASTM B209	5052	O, H112	25000	9500	8,15	6250	6250	6200	6000	5400	4650	3500
		H32	31000	23000	8,15	7750	7750	7650	7100	6400	5600	3500
		H34	34000	26000	8,15	8500	8500	8400	7700	6900	6100	3500
ASTM B209	5083	O	39000	17000	8	9750	9750					
ASTM B209	5086	O	35000	14000	8	8700	8700					
		H112	35000	14000	8,11,15	8700	8700					
		H32	40000	28000	8,15	10000	9900					
		H34	44000	34000	8,15	11000	10800					
ASTM B209	5154	O	30000	11000	8	7350	7350	7350	7000	6400		
		H112	30000	11000	8,11,15	7350	7350	7350	7000	6400		
		H32	36000	26000	8,15	9000	8950	8850	8250	7400		
		H34	39000	29000	8,15	9750	9700	9500	8800	7900		
ASTM B209	5456	O	41000	18000	8	10250	10150					
		H321	44000	33000	8,11,15	11000	10900					

8. For use in code piping at the stated allowable stresses, the required tensile properties must be verified by tensile test at the mill; such tests shall be specified in the purchase order.
9. Pressure temperature ratings of cast and forged parts as published in standards referenced in this Code may be used for parts meeting requirements of these standards. Allowable stresses for castings and forgings, where listed, are for use in design for special components not furnished in accordance with such standards.
11. Properties of this material vary with thickness or size. Stresses are based on minimum properties.
15. For welded construction with work hardened grades, use the stresses for annealed material; for welded construction with precipitation hardened grades, use the special allowable stresses for welded construction given in the Tables.

APPENDIX E

HOT TAPS, PURGING AND CLEARING

GENERAL

E1 All hot taps shall be installed by trained and experienced crews.

E2 Precautionary Measures

E2.1 No welding or acetylene cutting should be done on a piping system or auxiliary apparatus that contains air if it is connected to a source of gas, unless a suitable means has been provided to prevent the leakage of gas into the piping system.

E2.2 In situations where welding or cutting must be done on facilities which are filled with air and connected to a source of gas and the precautions recommended above cannot be taken, one or more of the following precautions, depending upon circumstances at the job, are suggested:

(a) Purging of the pipe or equipment upon which welding or cutting is to be done, with a non-combustible gas or inert gas.

(b) Testing of the atmosphere in the vicinity of the zone to be heated before the work is started and at intervals as the work progresses, with a combustible gas indicator or by other suitable means.

(c) Careful verification before the work starts that the valves that isolate the work from a source of gas do not leak and are properly tagged.

E2.3 Whenever the accidental ignition in the open air of a gas-air mixture might be likely to cause personal injury, or property damage, precautions shall be taken as, for example:

(a) Prohibit smoking and open flames in the area, and

(b) Install a metallic bond around the location of cuts in gas pipes to be made by other means than cutting torches, and

(c) Take precautions to prevent static electricity sparks, and

(d) Provide a fire extinguisher of a class approved by the National Fire Protection Association, or the National Board of Fire Underwriters.

E3 Purging and Clearing

E3.1 When a piping system full of air is placed in service, the air may be safely cleared with gas provided that a moderately rapid and continuous flow of gas is introduced at one end of the line and the air is vented out the other end. The gas flow should be continued without interruption until the vented gas is free from air. The vent should then be closed.

E3.2 In cases where gas in a piping system is to be cleared with air and the rate at which air can be supplied to the line is too small to make a procedure similar to but the reverse of that described in E3.1 feasible, a slug of inert gas should be introduced to prevent the formation of an explosive mixture at the interface between gas and air. Nitrogen or carbon dioxide may be used for this purpose.

E3.3 If a piping system containing gas is to be removed, the operation may be carried out in accordance with E3.2 or the line may be first disconnected from all sources of gas and then thoroughly cleared with air, water, steam or with inert gas before any further cutting or welding is done.

E3.4 If a piping system or auxiliary equipment is to be filled with air after having been in service and there is a reasonable possibility that the inside surfaces of the facility are wetted with a volatile flammable liquid, or if such liquids might have accumulated in low places, purging procedured designed to meet this situation shall be used. Steaming of the facility until all flammable liquids have been evaporated and swept out is recommended. Filling of the facility with

an inert gas and keeping it full of such gas during the progress of any work that might ignite an explosive mixture in the facility is an alternative recommendation. The possibility of striking static sparks within the facility shall not be overlooked as a possible source of ignition.

E3.5 Suitable precautions shall be taken whenever a piping system which is full of air is cleared with a combustible gas. If practical, the gas and air should be cleared to a safe location outside of the building. In no event should the piping be cleared into an area where there is a possible source of ignition such as furnace or boiler rooms or locations where electrical motors, water heaters, etc., are installed. During the clearing operation, smoking shall be prohibited.

USA STANDARD CODE FOR PRESSURE PIPING

CODE FOR PRESSURE PIPING

Section 1	Power Piping Systems, B31.1.0	1967
Section 2	Industrial Gas and Air Piping Systems, B31.2	1968
Section 3	Petroleum Refinery Piping B31.3	1966
Section 4	Liquid Petroleum Transportation Piping, B31.4	1966
Section 5	Refrigeration Piping Systems, B31.5	1967
Section 6	*Chemical Process Piping, B31.6	in preparation
Section 7	Nuclear Power Piping	1969
Section 8	Gas Transmission and Distribution Piping Systems, B31.8	1968

*Until publication of the new section, consult the B31 Case No. 49 issued April 1961

(Excerpt from Case No. 49: Chemical process piping may be designed, fabricated, inspected, and tested in accordance with the requirements of B31.3, Petroleum Refinery Piping.)

A complete list of USA Standards published by The American Society of Mechanical Engineers obtainable upon request.