

ASME B31.9-2014
(Revision of ASME B31.9-2011)

Building Services Piping

ASME Code for Pressure Piping, B31

AN AMERICAN NATIONAL STANDARD



**The American Society of
Mechanical Engineers**

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**The American Society of
Mechanical Engineers**

Two Park Avenue • New York, NY • 10016 USA

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FOREWORD

The need for a national code for pressure piping became increasingly evident from 1915 to 1925. The American Standards Association (ASA) initiated the B31 Project in March 1926 to meet that need. The American Society of Mechanical Engineers (ASME) proposed the work and has served as sponsor since its inception.

The first edition was published in 1935 as the American Tentative Standard Code for Pressure Piping. To keep the Code abreast of developments in design, welding, and of new standards and specifications, as well as of developments in service conditions, new or supplementary editions were issued as follows:

B31.1-1942	American Standard Code for Pressure Piping
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

In 1955, a decision was made to develop and publish separate Code Sections for various industries. The current Sections are

B31.1	Power Piping
B31.3	Process Piping
B31.4	Pipeline Transportation Systems for Liquids and Slurries
B31.5	Refrigeration Piping and Heat Transfer Components
B31.8	Gas Transmission and Distribution Piping Systems
B31.9	Building Services Piping
B31.12	Hydrogen Piping and Pipelines

In 1969, ASA, renamed the United States of America Standards Institute (USASI), became the American National Standards Institute (ANSI), and the B31 Sectional Committee became the B31 Standards Committee. In 1978, ASME was granted accreditation by ANSI to organize the B31 Committee as the ASME Code for Pressure Piping, with Code Sections designated as ANSI/ASME B31.

Need for a separate Building Services Section of the Code for Pressure Piping was recognized for several years. This new Code Section, ASME B31.9 Building Services Piping, first issued in 1982, was developed to fill that need.

The Code has intentionally been written on a conservative basis in order to avoid the necessity for complex design, fabrication, and inspection criteria. For this reason, application of this Code is expected to be simple and straightforward.

Metric (SI) units have been added in parentheses after U.S. Customary units. This Code is based on U.S. Customary units. The 2008 edition was approved by ANSI on April 1, 2008, and designated as ASME B31.9-2008.

The 2011 edition of B31.9 contained revisions to the definitions and materials section of the Standard. Additionally, the allowable stress values were updated to the 3.5 design margin.

The 2014 edition of B31.9 includes revisions to materials and the standards for material specifications, and other errata found in the Code.

Following approval by the B31 Main Committee and the ASME Board on Pressure Technology Codes and Standards, and after public review, this Code Section was approved by ANSI on March 18, 2014.

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Code for Pressure Piping

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INTRODUCTION

The ASME B31 Code for Pressure Piping consists of a number of individually published Sections, each an American National Standard. Hereafter, in this Introduction and in the text of this Code Section B31.9, where the word *Code* is used without specific identification, it means this Code Section.

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

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

(a) This Code Section includes

- (1) references to acceptable material specifications and component standards, including dimensional requirements and pressure-temperature ratings
- (2) requirements for design of components and assemblies, including pipe supports
- (3) requirements and data for evaluation and limitation of stresses, reactions, and movements associated with pressure, temperature changes, and other forces
- (4) guidance and limitations on the selection and application of materials, components, and joining methods
- (5) requirements for the fabrication, assembly, and erection of piping
- (6) requirements for examination, inspection, and testing of piping

It is intended that this Edition of Code Section B31.9 not be retroactive. Unless agreement is specifically made between contracting parties to use another issue, or the regulatory body having jurisdiction imposes the use of another issue, the latest edition issued at least 6 months prior to the original contract date for the first phase of activity covering a piping system or systems shall be the governing document for all design, materials, fabrication, erection, examination, and testing for the piping until the completion of the work and initial operation.

Users of this Code are cautioned against making use of revisions without assurance that they are acceptable to the proper authorities in the jurisdiction where the piping is to be installed.

Code users will note that clauses in the Code are not necessarily numbered consecutively. Such discontinuities result from following a common outline, insofar as practicable, for all Code Sections. In this way, corresponding material is correspondingly numbered in most Code Sections, thus facilitating reference by those who have occasion to use more than one Section.

The Code is under the direction of ASME Committee B31, Code for Pressure Piping, which is organized and operates under ASME procedures that have been accredited by the American National Standards Institute. The Committee is a continuing one and keeps all Code Sections current with new developments in materials, construction, and industrial practice. New editions are published at intervals of 3 to 5 years.

It is the owner's responsibility to select the Code Section that most nearly applies to a proposed piping installation. Different Code Sections may apply to different parts of an installation. Factors to be considered by the owner include: limitations of the Code Section, jurisdictional requirements, and the applicability of other codes and standards. All applicable requirements of the selected Code Section shall be met, and the owner should impose additional requirements supplementing those of the Code in order to ensure safe piping for the proposed installation.

(b) Rules for each Code Section have been developed considering the need for application specific requirements for the pressure piping involved. Applications considered for each Code Section include

(1) *B31.1, Power Piping* — piping typically found in electric power generating stations, industrial and institutional plants, geothermal heating systems, and central and district heating and cooling systems

(2) *B31.3, Process Piping* — piping typically found in petroleum refineries; chemical, textile, paper, semiconductor, and cryogenic plants; and related processing plants and terminals

(3) *B31.4, Pipeline Transportation Systems for Liquids and Slurries* — piping for transporting predominantly liquid products between plants and terminals and within terminals, and for pumping, regulating, and metering stations

(4) *B31.5, Refrigeration Piping and Heat Transfer Components* — piping for refrigerants and secondary coolants

(5) *B31.8, Gas Transportation and Distribution Piping Systems* — piping for transporting predominantly gas products between sources and terminals, including compressor, regulating, and metering stations; and gas gathering pipelines

(6) *B31.9, Building Services Piping* — piping for industrial, institutional, commercial, and public buildings, and multi-unit residences, which does not require the range of sizes, pressures, and temperatures covered in B31.1

(7) *B31.12, Hydrogen Piping and Pipelines* — piping in gaseous and liquid hydrogen service, and pipelines in gaseous hydrogen service

(c) Certain piping within a facility may be subject to other codes and standards, including but not limited to

(1) *ASME Boiler and Pressure Vessel Code, Section III* — nuclear power piping

(2) *ANSI Z223.1, National Fuel Gas Code* — fuel gas piping from the point of delivery to the connections of each gas utilization device

(3) *NFPA Fire Protection Standards* — fire protection systems using water and other materials such as carbon dioxide, halon, foam, dry chemicals, and wet chemicals

(4) *NFPA 85, Boiler and Combustion Systems Hazards Code*

(5) *NFPA 99, Health Care Facilities* — medical and laboratory gas systems

The Committee has established an orderly procedure to consider requests for interpretation and revision of Code requirements. To receive consideration, inquiries must be in writing and must give full particulars (see Mandatory Appendix IV, Preparation of Technical Inquiries). The approved reply to an inquiry will be sent directly to the inquirer. In addition, the question and reply will be published as part of an Interpretation Supplement issued to the applicable Code Section.

A Case is the prescribed form of reply to an inquiry when study indicates that the Code wording needs clarification or when the reply modifies existing requirements of the Code or grants permission to use new materials or alternative constructions. Proposed Cases are published in *Mechanical Engineering* for public review. In addition, the Case will be published as part of a Case Supplement issued to the applicable Code Section.

A Case is normally issued for a limited period, after which it may be renewed, incorporated in the Code, or allowed to expire if there is no indication of further need for the requirements covered by the Case. However, the provisions of a Case may be used after its expiration or withdrawal, provided the Case was effective on the original contract date or was adopted before completion of the work, and the contracting parties agree to its use.

Materials are listed in the Stress Tables only when sufficient usage in piping within the scope of the Code has been shown. Materials may be covered by a Case. Requests for listing shall include evidence of satisfactory usage and specific data to permit establishment of allowable stresses, maximum and minimum temperature limits, and other restrictions. (To develop usage and gain experience, unlisted materials may be used in accordance with para. 923.1.2.)

Requests for interpretation and suggestions for revision should be addressed to the Secretary, ASME B31 Committee, Two Park Avenue, New York, NY 10016-5990.

ASME B31.9-2014

SUMMARY OF CHANGES

Following approval by the B31 Committee and ASME, and after public review, ASME B31.9-2014 was approved by the American National Standards Institute on March 18, 2014.

ASME B31.9-2014 includes editorial changes, revisions, and corrections identified by a margin note, **(14)**, placed next to the affected area.

<i>Page</i>	<i>Location</i>	<i>Change</i>
viii	Introduction	(1) References to “addenda” deleted (2) ASME B31 Code Section list updated
2	Figure 900.1.2	Under “Administrative Jurisdiction and Technical Responsibility,” in the “Boiler Proper” callout, cross reference to ASME BPVC Section I updated
14	904.5.1	Cross reference to ASME BPVC Section VIII-1 updated
	904.7.2	Cross reference to ASME BPVC Section VIII-2 updated
18, 19	Table 919.3.1	New materials added
25	922.1.1	Last sentence revised
	922.1.2	Last sentence of subpara. (a) revised
29, 31	Table 926.1	(1) ASME PCC-1 added (2) ASTM standard titles revised
33	Table 926.2	(1) Title of ASTM F2014 revised (2) ASTM F2389 added
41	935.1	Revised
53	Table I-2	ASTM F2389 added
58–60	Mandatory Appendix III	Revised

BUILDING SERVICES PIPING

Chapter I Scope and Definitions

900 GENERAL

This Building Services Piping Code is a Section of The American Society of Mechanical Engineers Code for Pressure Piping, B31. This Section, herein called the Code, is published as a separate document for convenience.

Standards and specifications incorporated by reference in this Code are shown in Table 926.1, Mandatory Appendix I, and elsewhere. It is not considered practical to refer to a dated edition of each standard or specification where referenced. Instead, the dated edition references are included in Mandatory Appendix III.

The user is cautioned that the local building code must be observed and adhered to when its requirements are more stringent than those of this Code.

Components of piping systems shall conform to the specifications and standards listed in this Code. Piping elements neither specifically approved nor specifically prohibited by this Code may be used provided they are qualified for use as set forth in applicable chapters of this Code.

Engineering requirements of this Code, while considered necessary and adequate for safe design, generally employ a simplified approach. An engineer capable of applying a more rigorous analysis shall have the latitude to do so. He must be able to demonstrate the validity of his approach.

900.1 Scope

900.1.1 Coverage and Application. This Code Section has rules for the piping in industrial, institutional, commercial, and public buildings, and multi-unit residences, which does not require the range of sizes, pressures, and temperatures covered in B31.1. This Code prescribes requirements for the design, materials, fabrication, installation, inspection, examination, and testing of piping systems for building services. It includes piping systems in the building or within the property limits.

900.1.2 Services and Limits

(a) *Services.* This Code applies to the following building services, except as excluded in para. 900.1.3:

- (1) water and antifreeze solutions for heating and cooling
- (2) condensing water
- (3) steam or other condensate
- (4) other nontoxic liquids
- (5) steam
- (6) vacuum
- (7) compressed air
- (8) other nontoxic, nonflammable gases
- (9) combustible liquids including fuel oil

(b) *Boiler External Piping.* The scope of this Code includes boiler external piping within the following limits:

- (1) for steam boilers, 15 psig (103 kPa gage) max.
- (2) for water heating units, 160 psig (1 103 kPa gage) max. and 250°F (121°C) max.

Boiler external piping above these pressure or temperature limits is within the scope of ASME B31.1. Boiler external piping is the piping connected to the boiler and extending to the points identified in Fig. 900.1.2.

(c) *Material and Size Limits.* Piping systems of the following materials are within the scope of this Code, through the indicated maximum size (and wall thickness if noted):

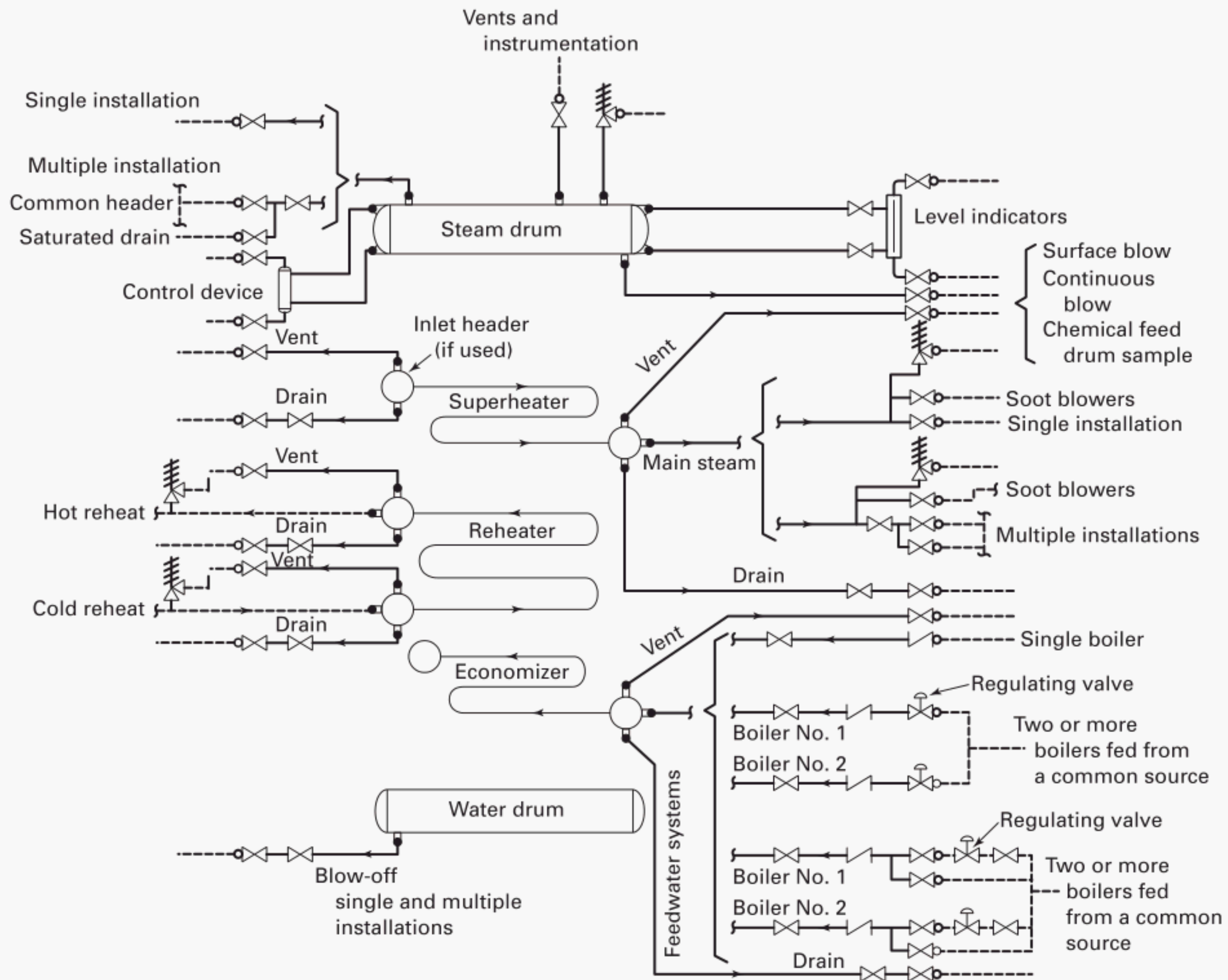
- (1) carbon steel: NPS 48 (DN 1 200) and 0.50 in. (12.7 mm) wall
- (2) stainless steel: NPS 24 (DN 600) and 0.50 in. (12.7 mm) wall
- (3) aluminum: NPS 12 (DN 300)
- (4) brass and copper: NPS 12 (DN 300) and 12.125 in. (308 mm) O.D. for copper tubing
- (5) thermoplastics: NPS 24 (DN 600)
- (6) ductile iron: NPS 48 (DN 1 200)
- (7) reinforced thermosetting resin: 24 in. (600 mm) nominal

Other materials may be used as noted in Chapter III.

(d) *Pressure Limits.* Piping systems with working pressures not in excess of the following limits are within the scope of this Code:

- (1) steam and condensate: 150 psig (1 034 kPa g)
- (2) liquids: 350 psig (2 413 kPa g)
- (3) vacuum: 1 atm external pressure

(14)

Fig. 900.1.2 Code Jurisdictional Limits for Piping — Drum-Type Boilers**Administrative Jurisdiction and Technical Responsibility**

- Boiler Proper — The ASME Boiler and Pressure Vessel Code (ASME BPVC) has total administrative jurisdiction and technical responsibility. Refer to ASME BPVC Section I, Preamble.
- Boiler External Piping and Joint (BEP). See para. 900.1.2(b) for B31.9 Scope.
- Nonboiler External Piping and Joint (NBEP).

(4) compressed air and gas: 150 psig (1 034 kPa g)

(e) *Temperature Limits.* Piping systems with working temperatures not in excess of the following limits are within the scope of this Code:

(1) steam and condensate: 366°F (186°C)

(2) other gases and vapors: 200°F (93°C)

(3) other nonflammable liquids: 250°F (121°C)

The minimum temperature for all services is 0°F (−18°C).

900.1.3 Exclusions. This Code does not apply to economizers, heaters, pumps, tanks, heat exchangers, and equipment covered by the ASME Boiler and Pressure Vessel (BPV) Code.

900.2 Terms and Definitions

adhesive bond: a union of materials by means of an adhesive.

anchor: a structural attachment device or mechanism that prevents the movement of pipe due to thermal expansion, expansion joint thrust, and other loads.

arc welding: a group of welding processes that produce coalescence of metals by heating them with an arc, with or without the use of filler metal.

assembly: the joining together of two or more piping components.

automatic welding: welding with equipment that performs the welding operation without constant observation and adjustment of controls by a welding operator. The equipment may or may not perform the loading and unloading of the work.

backing: material placed at the root of a weld joint to support molten weld metal.

backing ring: backing in the form of a ring.

ball or swivel joint: a joint that permits pipe motion by means of rotation.

base metal (material): the metal (material) to be welded, brazed, soldered, or cut.

boiler external piping (BEP): see para. 900.1.2(b).

branch connection: the attachment of the end of a branch pipe to the run of a main pipe, with or without the use of a fitting. Figure 927.4.6-1 shows typical branch connections that do not use fittings.

brazing: a joining process that produces coalescence of metals by using a filler metal whose liquidus is above 800°F (427°C) and below the solidus of the base metals. Unlike brazing, the filler metal is *not* distributed in the joint by capillary attraction.

brazing: a joining process that produces coalescence of metals by heating to a suitable temperature and by using a filler metal whose liquidus is above 800°F (427°C) and below the solidus of the base metals. The filler metal is

distributed by capillary attraction between closely fitted joint surfaces.

brine: a liquid used for the transmission of heat without change of state in cooling systems, which is nonflammable or has a flash point above 150°F (66°C) as determined by the method of ASTM D93.

brittle failure: a pipe failure mode that exhibits no material deformation visible to the naked eye, e.g., stretching, elongation, or necking down, in the area of the break.

butt joint: a joint between two members aligned approximately in the same plane.

chilled water: water or an antifreeze solution used as a brine at a supply temperature below 60°F (16°C).

coalescence: the growing together or growth into one body of materials being welded, brazed, or soldered.

combustible liquid: a liquid having a flash point at or above 100°F (38°C).

consumable insert: backing in the form of filler metal that is melted into the root of the weld and fused with the base metals.

contractor: the entity responsible for fabrication and installation of piping and associated equipment.

crack: a fracture-type imperfection characterized by a sharp tip and high ratio of length and depth to opening displacement.

DN: metric designated pipe size. The number is the millimeter approximation of the inch pipe size using 1 in. equal to 25 mm. The pipe is still manufactured in inch sizes.

defect: an imperfection that by nature or accumulated effect renders a part of the piping unable to meet minimum applicable acceptance standards or specifications. A defect is cause for rejection.

deposited metal: filler metal that has been added during a welding operation.

design pressure: the pressure, equal to or greater than the highest working pressure, used to determine the minimum permissible wall thickness or component rating. See para. 901.2.

design temperature: the temperature equal to or higher than the highest working temperature, used in determining the required wall thickness or component rating. See para. 901.3.

design thickness: the sum of the minimum thicknesses required by the design conditions and corrosion, mechanical, and other allowances.

employer: the owner, manufacturer, fabricator, contractor, assembler, or installer responsible for the welding, brazing, and NDE performed by his organization, including procedure and performance qualifications.

engineer: the engineer as agent of the owner is the party responsible for design of piping systems to meet operating and safety standards.

engineering design: the detailed design for a piping installation, developed from the building systems requirements and conforming to Code requirements, including necessary drawings and specifications.

equipment connection: an integral part of equipment such as boilers, pressure vessels, heat exchangers, pumps, etc., designed for attachment of piping.

erection: the complete installation of a piping system, including field fabrication and assembly.

examination: any of a number of quality control operations that use visual or other methods to reveal imperfections (indications) and to evaluate their significance.

examiner: a person employed by the piping manufacturer, fabricator, or erector who is competent to perform examinations.

expansion joint: a component installed in a piping system for the purpose of absorbing dimensional changes, such as those caused by thermal expansion or contraction.

fabrication: bending, forming, cutting, machining, and joining of piping components into integral subassemblies ready for erection. Fabrication may be performed in the shop or in the field.

face of weld: the exposed surface of a weld on the side from which the welding was done.

filler metal (material): metal (material) to be added in welding, brazing, braze welding, or soldering.

fillet weld: a weld of approximately triangular cross section joining two surfaces approximately at right angles.

flammable liquid: a liquid having a closed cup flash point below 100°F (38°C).

flux: material used to dissolve, to prevent accumulation of, or to facilitate removal of oxides and other undesirable substances during welding, brazing, or soldering.

flux-cored arc welding (FCAW): an arc welding process that employs a continuous tubular filler metal (consumable) electrode having a core of flux for shielding. Added shielding may or may not be obtained from an externally supplied gas or gas mixture.

full fillet weld: a fillet weld whose size is equal to the thickness of the thinner member joined. See *size of weld*.

fusion: the melting together of filler and base material, or of base material only, that results in coalescence.

gas metal arc welding (GMAW): an arc welding process that employs a continuous solid filler metal (consumable) electrode. Shielding is obtained entirely from an externally supplied gas or gas mixture. (Some methods of this process have been called MIG or CO₂ welding.)

gas pocket: see *porosity*, the preferred term.

gas tungsten arc welding (GTAW): an arc welding process that employs a tungsten (nonconsumable) electrode. Shielding is obtained from a gas or gas mixture. Pressure may or may not be used and filler metal may or may not be used. (This process has sometimes been called TIG welding.)

gas welding: see *oxyfuel gas welding*.

groove weld: a weld made in the groove between two members.

header: see *main*.

heat affected zone (HAZ): that portion of the base metal which has not been melted, but whose mechanical properties or microstructure have been altered by the heat of welding, brazing, soldering, forming, or cutting.

heat fusion: a joining process in which melted surfaces of plastic pipe and fittings are engaged and held together under moderate pressure until cool.

imperfection: an abnormality or indication found during examination or inspection that is not necessarily a cause for rejection. See also *defect*.

inert gas: a gas that does not combine with or affect the base material or filler material.

inert gas metal arc welding: see *gas metal arc welding*, the preferred term.

inspection: any operation performed to assure the owner that the materials, components, fabrication, and installation are in accordance with the engineering design. Inspection may include review of certifications, welding procedure and welder qualifications, records of examinations and testing, and any examination that may be required by the engineering design.

inspector: the owner, or a person representing the owner (not employed by the manufacturer, fabricator, or erector when different from the owner) who performs an inspection.

joint design: the joint geometry together with the required dimensions.

joint penetration: the minimum depth a groove weld extends from its face into a joint, exclusive of reinforcement. Joint penetration may include root penetration. See *root penetration*.

liquidus: the lowest temperature at which a metal or alloy is completely liquid.

main: as used in this Code, a section of pipe to which a branch or branches are connected.

manual welding: welding wherein the entire welding operation is performed and controlled by hand.

maximum allowable stress: the maximum stress value that may be used in the design formulas for a given material and design temperature. Stress values tabulated in Mandatory Appendix I are for stress in tension.

may: as used in this Code, denotes permission or indifference; it is neither a requirement nor a recommendation.

mechanical joint: a pipe joint in which mechanical strength is developed by threaded, grooved, rolled, compressed, flared, or flanged pipe ends, with gasketed, caulked, or machined and mated surfaces for leak resistance.

melting range: the temperature range between solidus and liquidus of a metal.

miter joint: two or more straight sections of pipe joined (in pairs) on a line bisecting the angle of junction so as to produce a change in direction.

nominal: a dimension of a product as given in a standard or specification, prior to consideration of tolerances; also, a designated size or rating, not necessarily an actual measurement.

nominal thickness: the thickness given in the product specification to which manufacturing tolerances are applied.

NPS: nominal pipe size.

owner: the party or organization responsible for the construction and operation of a facility. The owner is usually the one who has applied for, or who has been granted, a construction permit or operating license by the regulatory authority having jurisdiction.

oxidizing flame: an oxyfuel gas flame having an oxidizing effect due to excess oxygen.

oxyacetylene welding (OAW): a gas welding process in which coalescence is produced by heating with a gas flame or flames obtained from the combustion of acetylene with oxygen, with or without the application of pressure and with or without the use of filler metal.

oxyfuel gas welding (OFW): a group of welding processes in which coalescence is produced by heating with a flame or flames obtained from the combustion of fuel gas with oxygen, with or without the application of pressure, and with or without the use of filler metal.

oxygen cutting (OC): a group of cutting processes used to sever or remove metals by means of the reaction of oxygen with the base metal at elevated temperatures. In the case of oxidation-resistant metals, the reaction is facilitated by use of a chemical flux or metal powder.

pass: a single progression of a welding or surfacing operation along a joint, weld deposit, or substrate. The result of a pass is a weld bead, layer, or spray deposit.

peel test: a destructive method of examination that mechanically separates a lap joint by peeling.

peening: the mechanical working of metals using impact blows.

pipe: a pressure-tight cylinder used to convey a fluid or a fluid pressure, ordinarily designated *pipe* in applicable

material specifications. Materials designated *tube* or *tubing* in the specifications are treated as pipe when intended for pressure service.

pipe alignment guide: a restraint in the form of a sleeve or frame that permits the pipeline to move freely only along the axis of the pipe. See *restraint*.

pipe-supporting elements: these include the following:

fixtures: elements that transfer the load from the pipe or structural attachment to the support structure or equipment.

structural attachments: brackets, clips, lugs, or other elements welded, bolted, or clamped to the pipe. Support structures such as stanchions, towers, building frames, and foundations, and equipment such as vessels, exchangers, and pumps, are not considered pipe-supporting elements.

piping: assemblies of pipe and piping components used to convey, distribute, mix, separate, discharge, meter, and control fluid flows. Piping also includes pipe-supporting elements, but does not include support structures, such as building frames, bents, foundations, or any equipment excluded from this Code.

piping components: mechanical elements suitable for joining or assembly of pipe into pressure-tight fluid containing piping systems. Components include fittings, flanges, gaskets, bolting, valves, and devices such as expansion joints, flexible joints, pressure hoses, traps, strainers, in-line portions of instruments, and separators.

piping system: interconnected piping subject to the same set or sets of design conditions.

porosity: cavity-type imperfections formed by gas entrapment during solidification of weld metal.

postheating, also called *postweld heat treatment (PWHT)*: the application of heat to an assembly after a welding, brazing, soldering, cutting, or forming operation.

preheating (PH): the application of heat to the base metal immediately before welding, brazing, soldering, cutting, or forming.

procedure: the detailed elements (with prescribed values or range of values) of a process or method used to produce a specific result.

procedure qualification: the demonstration that welds or other work produced by a specified procedure can meet prescribed standards.

purge gas: the replacement of air within a piping system with an inert gas; may be required by the welding procedure specification prior to making a gas tungsten arc weld.

qualification: see preferred terms, *procedure qualification* and *Welder Performance Qualification*.

recommend: has the same effect as *should*.

reducing flame: an oxyfuel gas flame having a reduced effect due to excess fuel gas.

reinforcement: in branch connections, reinforcement is material around a branch opening that serves to strengthen it. The material is either integral in the branch components or added in the form of weld metal, a pad, a saddle, or a sleeve. In welding, reinforcement is weld metal in excess of the specified weld size.

restraint: a structural attachment, device, or mechanism that limits movement of the pipe in one or more directions. See *pipe alignment guide*.

reverse polarity: the arrangement of direct current arc welding leads with the work as the negative pole and the electrode as the positive pole of the welding arc; a synonym for direct current electrode positive.

root opening: the separation between members to be joined at the root of the joint.

root penetration: the depth that a weld extends into the root of a joint measured on the centerline of the root cross section.

root reinforcement: weld reinforcement at the side other than that from which welding was done.

root surface: the exposed surface of a weld on the side other than that from which welding was done.

run: see *main*.

seal weld: a fillet weld used on a pipe joint primarily to obtain fluid tightness as opposed to mechanical strength; usually used in conjunction with a threaded joint.

semiautomatic arc welding: arc welding with equipment that controls only the filler metal feed. The advance of the welding is manually controlled.

shall: used to indicate that a provision or prohibition in this Code is required, i.e., mandatory.

shielded metal arc welding (SMAW): an arc welding process in which coalescence is produced by heating with an electric arc between a covered metal electrode and the work. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

should: used to indicate that a provision of this Code is not required but represents good practice.

single-welded butt joint: a butt joint welded from one side only.

size of weld

NOTE: When one member makes an angle with the other member greater than 105 deg, the leg length (size) is of less significance than the effective throat, which is the controlling factor in the strength of the weld.

fillet weld: for an equal leg fillet weld, the leg length of the largest isosceles right triangle that can be inscribed

within the fillet weld cross section. For an unequal leg fillet weld, the leg lengths of the largest right triangle that can be inscribed within the fillet weld cross section.

groove weld: the joint penetration (depth of bevel plus root penetration when specified). The size of a groove weld and its effective throat are the same.

slag inclusion: nonmetallic solid material trapped in the weld metal or between the weld metal and base metal.

solder: a filler metal used in soldering that has a liquidus not exceeding 800°F (427°C).

soldering: a group of joining processes that produces coalescence of metals by heating them to a suitable temperature and by using a filler metal having a liquidus not exceeding 800°F (427°C) and below the solidus of the base metals.

solidus: the highest temperature at which a metal or alloy is completely solid.

solvent cement: a solvent adhesive that dissolves or softens the surface being bonded so that the assembly becomes essentially a single fused piece.

solvent cementing: joining plastic parts by use of the appropriate solvent cement.

spacer strip: a metal strip or bar prepared for a groove weld and inserted in the root of a joint to serve as a backing and to maintain root opening during welding; it can also bridge an exceptionally wide gap due to poor fit-up.

spatter: in arc and gas welding, the metal particles expelled during welding that do not form part of the weld.

straight polarity: the arrangement of direct current arc welding leads in which the work is the positive pole and the electrode is the negative pole of the welding arc; a synonym for direct current electrode negative.

stringer bead: a type of weld bead made without appreciable weaving motion. See also *weave bead*.

submerged arc welding (SAW): an arc welding process that produces coalescence of metals by heating them with an arc or arcs drawn between a bare metal electrode or electrodes and the base metals. The arc is shielded by a blanket of granular fusible material. Pressure is not used and filler metal is obtained from the electrode and sometimes from a supplementary welding rod.

supplemental steel: structural members that frame between existing building framing steel members and are significantly smaller in size than the existing steel.

tack weld: a weld made to hold parts in proper alignment until final welds are made.

thermoplastic: a plastic that is capable of being repeatedly softened by heating and hardened by cooling, and whose change upon heating is substantially physical.

thermosetting resin: a plastic that, when cured by heat or chemical means, changes into a substantially infusible, insoluble product.

throat of a fillet weld

actual: the shortest distance from the root of a fillet weld to its face.

theoretical: the perpendicular distance from the beginning of the root of the joint to the hypotenuse of the largest right triangle that can be inscribed within the fillet weld cross section.

thrust block: a type of anchor consisting of a concrete block bearing against earth, usually used on an underground pipeline.

toe of weld: the junction between the face of a weld and the base metal.

tungsten electrode: a nonconsumable electrode used in arc welding, consisting of a tungsten wire.

undercut: a groove melted into the base metal adjacent to the toe or root of a weld, and left unfilled by weld metal.

weave bead: a type of weld bead made with transverse oscillation.

welder: one who is capable of performing a manual or semiautomatic welding operation.

welder certification: the action of determining, verifying, or attesting in writing that a welder is qualified to produce welds which can meet prescribed standards.

Welder Performance Qualification: demonstration of a welder's ability to produce welds in a manner described in a welding procedure specification that meets prescribed standards.

welding: a process in which a localized coalescence of metal is produced by heating to a suitable temperature, with or without pressure and with or without the use of filler metal. The filler metal has a melting point approximately the same as the base metals.

welding operator: one who operates a welding machine or automatic welding equipment.

welding procedure: the detailed methods and practices, including all joint welding procedures, involved in making a welded joint.

Welding Procedure Qualification: demonstration that welds made in a manner described in the Welding Procedure Specification will meet prescribed standards. The Procedure Qualification Record (PQR) describes the materials, methods, and results of the test.

Welding Procedure Specification (WPS): the written form of the welding procedure for making a specified kind of a welded joint using specified base and filler metals.

wetting: the condition in which a liquid filler metal or flux forms a zero angle of contact on a solid base metal surface.

900.3 Nomenclature

Symbols used in this Code are listed here with definitions. Upper and lower case English letters precede Greek letter symbols.

- A = thickness allowance for corrosion (see para. 902.4.1), for mechanical joint preparation (see para. 902.4.2), or for mechanical strength (see para. 902.4.4), in. (mm)
- a = weld size (attachment weld, back of slip-on or socket welding flange), in. (mm)
- B = internal area, greatest of pipe or expansion joint bellows, in.² (m²)
- b = weld size (attachment weld, face of slip-on flange), in. (mm)
- C = head or closure factor, dimensionless
- D = outside pipe diameter, as measured or per dimensional standard, in. (mm)
- D_n = diameter equal to nominal pipe size, in. (mm)
- d = inside pipe diameter ($D - 2T$), for use in closure and branch connection reinforcement calculations, in. (mm)
- d_g = inside diameter of gasket on raised or flat (plain) face flanges; or gasket pitch diameter for ring joint and fully retained gasketed flanges, in. (mm)
- E = longitudinal or spiral welded joint efficiency factor, dimensionless (Table 902.4.3)
- E_m = modulus of elasticity, psi (kPa) (Table 919.3.1)
- e = coefficient of thermal expansion, in./in./°F (mm/m/°C)
- F = casting quality factor, dimensionless
- f = stress range reduction factor for cyclic conditions, dimensionless
- h = thread depth in ASME B1.20.1, in. (mm)
- I = moment of inertia, in.⁴ (mm⁴)
- ksi = kips (1,000 lb) per square inch (MPa)
- L = developed length of pipe axis between anchors, ft (m)
- L_s = length of pipe between supports or guides, ft (m)
- N = number of stress or thermal cycles, dimensionless
- P = internal design pressure, psig (kPa)
- Q = force to overcome spring rate or friction of expansion joint and guides, pounds-force (lb/ft) (N/mm)
- R = anchor or support reaction, lbf (N)
- R_1 = effective radius of miter joint; the shortest distance from the pipe centerline to the intersection of planes of adjacent miter joints, in. (mm)
- r_2 = mean radius of pipe, based on nominal dimensions, in. (mm)
- S = basic allowable stress value prior to applying joint factor E , psi (kPa)
- S_A = allowable stress range, psi (kPa) [see para. 902.3.2(c)]

S_c = basic material allowable stress prior to applying joint factor E , at minimum (cold) normal temperature, psi (kPa)	T_n = nominal pipe thickness, in. (mm)
S_E = computed expansion stress range, psi (kPa)	t_c = minimum required thickness of flat head, closure, or blank, in. (mm)
S_F = maximum allowable stress in material due to internal pressure considering casting quality factor at design temperature, psi (kPa)	t_m = minimum required wall thickness, in. (mm) (see para. 904.1.1)
S_h = basic material allowable stress prior to applying joint factor E , at maximum (hot) normal temperature, psi (kPa)	t_w = weld throat size, in. (mm)
S_L = longitudinal compressive stress, psi (kPa)	U = distance between anchors, measured in a straight line, ft (m)
S_{LP} = longitudinal stress due to pressure, psi (kPa)	ν = Poisson's ratio, dimensionless
SE = maximum allowable stress in material due to internal pressure, considering joint efficiency factor E at design temperature, psi (kPa)	Y = resultant thermal movement to be absorbed by piping system, in. (mm)
T = measured or minimum specification wall thickness, exclusive of corrosion allowance, in. (mm)	α = lesser angle between axis of branch and axis of main, deg
	ΔT = temperature difference, °F (°C)
	θ = angle of miter cut (one-half the change in direction at a miter joint), deg

Chapter II Design

PART 1 CONDITIONS AND CRITERIA

901 DESIGN CONDITIONS

901.1 General

These design conditions define the pressures, temperatures, and other conditions applicable to the design of building services piping. Such systems shall be designed for the most severe conditions of coincident pressure, temperature, and loading anticipated under any conditions of normal operation, including start-up and shut-down. The most severe condition shall be that which results in the greatest required wall thickness and the highest component rating.

901.2 Pressure

Pressures referred to in this Code are expressed in pounds-force per square inch gage (psig), unless otherwise stated.

901.2.1 Internal Design Pressure. The internal design pressure, including the effects of static head, shall not be less than the maximum sustained fluid operating pressure within the piping system. Consideration should be given to possible pressure surges. Pump shut-off pressures shall be considered.

901.2.2 External Design Pressure. Piping subject to external pressure shall be designed for the maximum differential pressure anticipated in normal operation.

901.2.3 Required Containment or Relief. Provision shall be made to safely contain or relieve excessive pressure to which the piping may be subjected. Piping not protected by a pressure-relieving device, or that can be isolated from a pressure-relieving device shall be designed for at least the highest pressure that can be developed.

901.3 Temperature

Temperatures referred to in this Code are the temperatures of piping materials expressed in degrees Fahrenheit, unless otherwise stated. The piping shall be designed for a temperature representing the maximum condition expected.

The temperature of the piping materials is considered to be the same as that of the fluid in the piping.

901.4 Ambient Influences

901.4.1 Cooling, Effects on Pressure. Where the cooling of a fluid may reduce the pressure in the piping to below atmospheric, the piping shall be designed to withstand the external pressure, or provision shall be made to break the vacuum.

901.4.2 Fluid Expansion Effects. Where the expansion of a fluid may increase the pressure, the piping system shall be designed to withstand the increased pressure, or provision shall be made to relieve the excess pressure.

901.5 Dynamic Effects

(a) *General.* Piping shall be designed, arranged, and supported with due consideration of vibration, hydraulic shock, wind, and earthquake.

(b) *Seismic Analysis.* Seismic analysis and design for pipe supports and related structures shall be in accordance with the requirements of the governing building code for the jurisdiction in which the work is being performed.

901.6 Thermal Expansion and Contraction Loads

When a piping system is prevented from free thermal expansion and contraction as a result of anchors and restraints, thrusts and moments are set up that must be taken into account as set forth in paras. 902 and 919.

902 DESIGN CRITERIA

902.1 General

The provisions of para. 902 pertain to ratings, stress values, allowable stress criteria, design allowances, and minimum design values, and formulate the permissible variations in these factors when used in design of piping.

902.2 Pressure–Temperature Design Criteria for Piping Components

902.2.1 Components Having Specific Ratings

(a) *For Listed Components.* Pressure–temperature ratings have been established for certain piping components and are contained in some of the standards listed in Table 926.1. These ratings are accepted for use in accordance with this Code.

(b) *For Components Not Listed.* If it is necessary to use components that do not conform to standards listed in Table 926.1, they shall be qualified for pressure design

in accordance with the requirements of para. 904. In addition, they shall be used within the ratings and other service limitations given by the manufacturer.

902.2.2 Components Not Having Specific Ratings.

Components conforming to some of the standards listed in Table 926.1 are specified as having ratings equal to those of seamless pipe of corresponding material and wall thickness. For the purposes of this Code, these components shall be used as follows:

(a) Butt welding fittings shall be specified to a wall thickness at least as great as that of the pipe to which they are to be connected.

(b) Forged steel or alloy threaded and butt welding fittings shall be specified in the nominal pressure class at least as great as that listed for the wall thickness of pipe to which they are to be connected.

902.2.3 Ratings, Normal Design Conditions. A piping system shall be considered safe for operation if the maximum pressure that may act on any part or component of the system does not exceed the maximum pressure allowed by this Code, at the design temperature for that component; or does not exceed the rated pressure at design temperature for that component in the applicable standard listed in Table 926.1.

902.2.4 Ratings at Transitions. Where piping systems operating at different design conditions are connected, a division valve shall be provided, which shall be designed for the higher pressure–temperature condition.

902.3 Allowable Stresses and Other Stress Limits

902.3.1 Allowable Stress Values

(a) *General.* The allowable stresses to be used for design calculations shall conform to those in Mandatory Appendix I, unless modified by other requirements of this Code.

For pipe and tube that do not contain longitudinal or spiral joints, Mandatory Appendix I shows the basic allowable stress S .

For pipe and tube that contain longitudinal or spiral joints, Mandatory Appendix I shows the product of the basic allowable stress S and the longitudinal or spiral joint factor E . SE is then the allowable stress. For such materials, divide the value shown in the table by the joint factor E to obtain the basic allowable stress S for Code computations in which the joint factor need not be considered.

Allowable stresses for materials not listed in Mandatory Appendix I shall be as listed in ASME B31.1 or shall be determined using the bases in paras. 902.3.1(b) through (f), as applicable.

(b) *For Cast Iron.* Basic allowable stress values at temperature for cast iron (except as covered in para. 904.1.2) shall not exceed the lower of the following:

(1) one-tenth of specified minimum yield strength at room temperature

(2) one-tenth of tensile strength at temperature¹

(c) *For Malleable and Ductile Iron.* Basic allowable stress values at temperature for malleable and ductile iron shall not exceed the lower of the following:

(1) one-fifth of specified minimum tensile strength at room temperature

(2) one-fifth of tensile strength at temperature¹

(d) *Other Metals.* Basic allowable stress values for materials other than bolting materials, cast iron, and malleable iron shall not exceed the lowest of the following:

(1) one-fourth of specified minimum tensile strength at room temperature

(2) one-fourth of tensile strength at temperature¹

(3) two-thirds of specified minimum yield strength at room temperature

(4) two-thirds of yield strength at temperature¹

(e) *Thermoplastics.* The basic allowable stress for pressure design only of thermoplastic materials shall be one-half the hydrostatic design basis at the design temperature, as determined from test data obtained in accordance with ASTM D1598 or analyzed in accordance with ASTM D2837.

(f) *Reinforced Thermoset Resins.* The basic allowable stress for pressure design only of reinforced thermosetting resin materials shall be one-half the hydrostatic design basis at the design temperature, as determined from test data obtained in accordance with ASTM D1598, or analyzed in accordance with Procedure B of ASTM D2992. Data obtained by the method of ASTM D2143 may be used if analyzed by Procedure A of ASTM D2992.

(g) *Shear and Bearing Stresses.* Allowable stress values in shear shall be 0.80 times, and allowable stress values in bearing shall be 1.60 times, the basic allowable stress value S .

(h) *Pipe Support Elements.* For allowable stresses, see para. 921.1.1.

902.3.2 Limits of Calculated Stresses Due to Sustained Loads and Thermal Expansion or Contraction

(a) *Internal Pressure Stresses.* The calculated stress due to internal pressure shall not exceed the allowable stress values SE given in Mandatory Appendix I except as permitted elsewhere in para. 902.3.

(b) *External Pressure Stresses.* Stresses due to external pressure shall be considered acceptable when the wall thickness of the piping component and its means of stiffening meet the requirements of paras. 903 and 904.

(c) *Stresses Due to Expansion and Contraction.* The allowable stress range S_A for expansion stresses in systems stressed primarily in bending and torsion shall be

¹ The tensile (or yield) strength at temperature is derived by multiplying the average expected tensile (or yield) strength at temperature by the ratio of the specified minimum tensile (or yield) strength at room temperature to the average expected tensile (or yield) strength at room temperature.

determined in accordance with ASME B31.1, para. 102.3.2(B), using basic allowable stresses S from Mandatory Appendix I of this Code.

(d) *Additive Stresses.* The sum of the longitudinal stresses due to pressure, weight, and other sustained loads shall not exceed the allowable stress in the hot condition S_h . Where the sum of these stresses is less than S_h , the difference between S_h and this sum may be added to the term $0.25S_h$ in eq. (1A) of ASME B31.1, para. 102.3.2(B) for determining the allowable stress range S_A .

(e) *Longitudinal Pressure Stress.* The longitudinal pressure stress S_{LP} is determined by dividing the end force due to internal pressure by the cross-sectional area of the pipe wall.

902.3.3 Limits of Calculated Stresses Due to Occasional Loads

(a) *Operation.* The sum of the longitudinal stresses produced by pressure, live and dead loads, and those produced by occasional loads, such as wind or earthquake, shall not exceed 1.33 times the allowable stress values S in Mandatory Appendix I. It is not necessary to consider wind and earthquake as occurring concurrently.

(b) *Test.* Stresses due to test conditions are not subject to the limitations of para. 902.3. It is not necessary to consider other occasional loads, such as wind and earthquake, as occurring concurrently with the live, dead, and test loads existing at the time of the test.

902.4 Allowances

902.4.1 Corrosion or Erosion. When corrosion or erosion is expected, the wall thickness shall be increased over that required by other design requirements, unless other means of corrosion control such as coatings or cathodic protection are relied on. This allowance shall be consistent with the expected life of the piping, as judged by the engineer.

902.4.2 Threading and Grooving. The calculated minimum thickness of metallic pipe or tubing that is to be threaded shall be increased by an allowance equal to thread depth, dimension h in ASME B1.20.1, or equivalent. For machined surfaces or grooves if the tolerance is not specified, it shall be assumed to be $\frac{1}{64}$ in. (0.4 mm) in addition to the specified depth of cut.

For plastic pipe, the recommendations for threading and derating in the applicable standard listed in Table 926.1 shall be followed.

902.4.3 Joint Efficiency Factors. Longitudinal or spiral weld joint efficiency factors are required by this Code and are included in the allowable stress values SE in Mandatory Appendix I. Table 902.4.3 states the factor E for several types of longitudinal or spiral welds.

Table 902.4.3 Joint Factors, E

Type of Longitudinal or Spiral Joint	Weld Joint Efficiency Factor, E
Single butt weld	0.80
Double butt weld	0.90
Single or double butt weld with 100% radiography or ultrasonic examination [Note (1)]	1.00
Electric resistance weld	0.85
Furnace butt weld (or continuous weld)	0.60
ASTM A211 spiral joint	0.75

NOTE:

(1) Acceptance standards are those in ASME B31.1.

902.4.4 Mechanical Strength. The wall thickness of pipe should be increased where necessary for mechanical strength to prevent damage, collapse, excessive sag, or buckling of pipe due to superimposed loads from supports or other causes; or, if this is impractical or would cause excessive local stresses, the superimposed loads shall be reduced or eliminated by other design methods.

PART 2

PRESSURE DESIGN OF PIPING COMPONENTS

903 CRITERIA FOR PRESSURE DESIGN OF PIPING COMPONENTS

Components manufactured in accordance with the specifications and standards listed in Table 926.1 or in Mandatory Appendix I shall be considered suitable for use at the pressure-temperature ratings or allowable stresses in accordance with para. 902.2. Components not manufactured in accordance with those specifications and standards shall be used only in accordance with para. 902.2.2.

The rules in para. 904 usually are for the pressure design of components not covered in para. 902.2 but may be used for a more rigorous or special design of components covered in para. 902.2. The designs shall be checked for adequacy of mechanical strength under applicable loadings stated in para. 901.

904 PRESSURE DESIGN OF COMPONENTS

904.1 Straight Pipe

904.1.1 Straight Pipe Under Internal Pressure

(a) *Steel, Alloy, and Nonferrous Pipe.* The minimum wall thickness of pipe wall, including allowances, shall not be less than that determined by eq. (1).

$$t_m = \frac{PD}{2SE} + A \quad (1)$$

Design pressure shall not exceed that determined by eq. (2).

$$P = \frac{2SE(t_m - A)}{D} \quad (2)$$

The engineer may, at his option, use the values of t_m and P determined by the applicable equations in ASME B31.1.

(1) If pipe is ordered by its nominal wall thickness, the manufacturing tolerances on wall thickness must be taken into account. After the minimum wall thickness t_m is determined, this minimum thickness shall be increased to provide the manufacturing tolerance allowed in the applicable pipe specification. The next heavier commercial wall thickness shall then be selected.

(2) When computing the design pressure for a pipe of a definite minimum wall thickness t_m , the value of pressure obtained by eq. (2) may be rounded to the next higher increment of 10 psi (69 kPa).

(b) *Ductile Iron Pipe.* The thickness of ductile iron pipe shall be determined from one of the following:

- (1) ANSI/AWWA C150/A21.50 or C151/A21.51
- (2) ANSI A21.14 or A21.52
- (3) Federal Specification WW-P-421

The tabulated thicknesses in these standards include allowances for foundry tolerances and water hammer.

(c) *Straight Nonmetallic Pipe.* The maximum pressure ratings for plastic and other nonmetallic pipe shall be as given in the applicable standards listed in Table 926.1.

904.1.2 Straight Metallic Pipe Under External Pressure. In determining wall thickness and stiffening requirements for straight pipe under external pressure, the procedures outlined in UG-28 of Section VIII, Division 1 of the ASME BPV Code shall be followed.

904.2 Curved and Mitered Segments of Pipe

904.2.1 Pipe Bends

(a) *Thickness of Bends.* The minimum wall thickness t_m at any point in a completed pipe bend shall not be less than that required by para. 904.1.1. Table 904.2.1 may be used as a guide in specifying wall thickness for ordering pipe to be bent.

(b) *Flattening of Bends.* Flattening of a bend, as measured by the difference of maximum and minimum diameters, shall not exceed 8% of the average measured outside diameter of the pipe before bending.

Greater flattening may be permitted or less flattening may be required if specified by the engineering design.

904.2.2 Miter Joints. Thickness determined in accordance with para. 904.1.1 does not allow for discontinuity stresses at the joint between mitered segments of pipe. These discontinuity stresses are negligible for miter angles of 3 deg or less in any service, and may be neglected for miters in nonflammable, nontoxic liquid service at pressures of 50 psig (345 kPa) or less, and

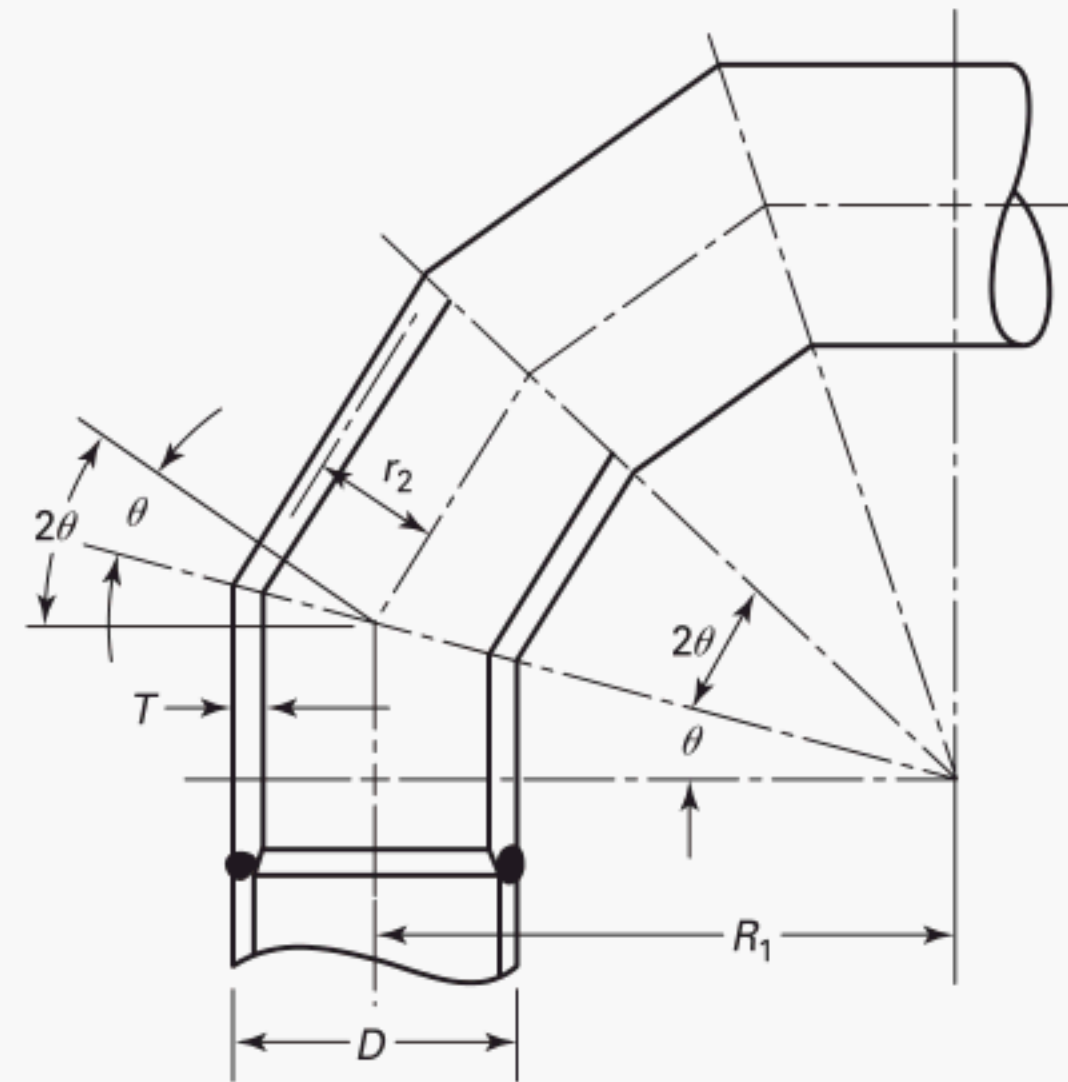
Table 904.2.1 Pipe Thickness for Bends

Radius of Bends, Pipe Diameters, D_n [Note (1)]	Minimum Thickness Recommended Prior to Bending, t_m
6 or greater	1.06
5	1.08
4	1.14
3	1.24

NOTE:

- (1) Interpolation is permissible for a radius other than those listed.

Fig. 904.2.2 Nomenclature for Miter Joints



for unvalved vents to atmosphere. See Fig. 904.2.2 for nomenclature.

(a) *Allowable Pressure.* For other services and for pressures in excess of 50 psig (345 kPa), the maximum allowable pressure for miter joints where θ does not exceed $22\frac{1}{2}$ deg shall be the lower positive value calculated by eqs. (3A) and (3B).

$$P = \frac{SET}{r_2} \left(\frac{T}{T + 0.64 \tan \theta \sqrt{r_2 T}} \right) \quad (3A)$$

$$P = \frac{SET}{r_2} \left(\frac{R_1 - r_2}{R_1 - 0.5r_2} \right) \quad (3B)$$

Equations (3A) and (3B) apply only when R_1 is at least as great as the value calculated by eq. (4).

(U.S. Customary Units)

$$R_1 = \frac{1}{\tan \theta} + \frac{D}{2} \quad (4)$$

(SI Units)

$$R_1 = \frac{25.4}{\tan \theta} + \frac{D}{2}$$

(b) *Other Miters.* Miter joints not covered above shall meet the requirements of para. 904.7.

904.3 Branch Connections

904.3.1 General. In para. 904.3, requirements are presented for design of branch connections in which the angle between the axes of the branch and main is 45 deg to 90 deg, inclusive, and the axes intersect. Branch connections may be made by any of the following methods:

(a) *Fittings.* Tees, extruded outlets, laterals, crosses, etc., manufactured in accordance with a standard listed in Table 926.1.

(b) *Outlet Fittings.* Cast or forged, integrally reinforced, welding outlet fittings, nozzles, forged couplings, and similar items, attached to the main by welding.

(c) *Direct Connection to the Main.* Welding the branch pipe directly to the main, with or without added reinforcement, as shown in details of branch connections in Figs. 927.4.6-1 and 927.4.6-2 and the rules of para. 904.3.2.

(d) *Mechanically Formed Tee Connections in Copper Tube.* See para. 930.2.

904.3.2 Strength of Branch Connections

(a) *General.* A main having a branch connection is weakened by the branch opening. Unless the wall thickness of the main and branch are sufficiently in excess of that required to sustain the pressure, it is necessary to provide added reinforcement.

(b) *Multiple Openings.* In the case of multiple openings in the main, the rules of this paragraph are applicable only if the distance between their centers is at least the sum of their inside diameters, d . Otherwise, the requirements in para. 104.3.1(G.7) of ASME B31.1 must be met.

(c) *Branch Connections Not Requiring Added Reinforcement.* It may be assumed without calculation that a branch connection has adequate strength to sustain the internal and external pressure that will be applied to it if

(1) the branch connection utilizes a fitting (tee, lateral, or cross) in accordance with para. 903.

(2) the branch connection is made by welding a threaded or socket-welding coupling or half coupling directly to the main, when the branch size does not exceed NPS 2 (DN 50) or one-fourth the nominal diameter of the main. The minimum wall thickness of the coupling shall be not less than that of the unthreaded branch pipe. See Fig. 927.4.6-2 for permissible welds.

(3) the branch connection is made by welding an integrally reinforced outlet fitting (having a threaded, socket, or butt-welding outlet) to the main, provided the fitting is made from materials listed in Mandatory Appendix I, and provided it has been demonstrated by full-scale internal pressure tests or other means described in para. 904.7 that the branch fitting and its joint are at least as strong as the main or branch pipes.

(4) the branch connection design pressure is less than the pressure, P , obtained from eq. (5), when solved for the configuration of the joint. The equation gives the maximum pressure allowed without reinforcement by equating the removed required area in the main to the inherent excess areas in the main and branch. If the design pressure is higher than P , see para. 904.3.3.

$$P = \frac{SE_m SE_b [T_m(D_b - 2T_b) + T_b^2(5 + \sin \alpha)]}{SE_b D_m(D_b - 2T_b) + 5SE_m T_b D_b} \quad (5)$$

where

D_b = the O.D. of the branch pipe, in. (mm)

D_m = the O.D. of the main (run) pipe, in. (mm)

P = the maximum pressure of the joint without reinforcement, psi (kPa)

SE_b = the allowable stress for the branch pipe material, psi (kPa)

SE_m = the allowable stress of the main (run) pipe material, psi (kPa) (For welded pipe, $E = 1.0$ if the weld in the main does not intersect the branch joint.)

T_b = the thickness of the branch less the manufacturing tolerance and less the corrosion allowance, if any, in. (mm)

T_m = the thickness of the main net of manufacturing tolerance and a corrosion allowance, in. (mm)

α = the angle between the axis of the main and the axis of the branch pipe

904.3.3 Reinforcement of Branch Connections. If added reinforcement is required for a branch connection as determined by para. 904.3.2(c)(4), the criteria for such reinforcement along with rules for proportioning and attaching such reinforcement are given in para. 104.3.1(D) of ASME B31.1.

904.3.4 Extruded Outlet Headers. If integrally reinforced extruded outlet headers are used, they shall be reinforced as required by para. 104.3.1(G) of ASME B31.1.

904.4 Closures

904.4.1 General. Closures shall be made by use of closure fittings, such as plugs, caps, or blind flanges in accordance with para. 903, or by use of flat plate closures such as those shown in Fig. 927.4.5-1. Flat plate closures shall not be secured with a single fillet weld.

The minimum required thickness, t_c , for flat plate closures is calculated by eq. (6).

$$t_c = d\sqrt{CP/S} + A \quad (6)$$

where

$C = 0.5t_m/T$, but not less than 0.3

$S =$ allowable stress of closure material

904.4.2 Openings in Closures. Openings in closures may be made by welding, extruding, or threading. Attachment to the closure shall be in accordance with the requirements for the corresponding type of branch connection in para. 904.3.3, including the need and provision for added reinforcement. If the size of the opening is greater than half the inside diameter of the closure, the opening shall be designed as a reducer in accordance with para. 904.6.

904.5 Pressure Design of Flanges and Blanks

- (14) **904.5.1 General.** Flanges manufactured in accordance with a standard listed in Table 926.1 are suitable for use in accordance with para. 903. Other flanges shall be designed in accordance with Mandatory Appendix 2, Section VIII, Division 1 of the ASME BPV Code.

904.5.2 Blind Flanges. Blind flanges manufactured in accordance with a standard listed in Table 926.1 are suitable for use in accordance with para. 903. Other blind flanges shall be designed in accordance with UG-34 of Section VIII, Division 1 of the ASME BPV Code.

904.5.3 Blanks. The minimum required thickness of a permanent blank installed between two flanges shall be calculated by eq. (7).

$$t_c = d_g\sqrt{3P/16S} + A \quad (7)$$

where

$S =$ allowable stress of blank material. Use S_F if material is a casting.

Blanks used only for testing with an incompressible fluid shall be calculated in accordance with eq. (7), except that P shall be the test pressure and S may be taken as 0.95 times the specified minimum yield strength of the blank material.

904.6 Reducers

904.6.1 General. Reducers manufactured in accordance with a standard listed in Table 926.1 are suitable for use with pipe of the same nominal thickness.

904.6.2 Segmented Reducers. The minimum wall thickness of segmented (orange peel) reducers fabricated with longitudinal welds shall be determined in accordance with para. 904.1.2, using a weld joint efficiency factor of 0.6. The slope of the reducing section shall not be at an angle greater than 30 deg to the axis of the pipe.

904.7 Pressure Design of Other Pressure Containing Components

904.7.1 Listed Components. Other pressure containing components manufactured in accordance with a standard listed in Table 926.1 are suitable for use in accordance with para. 903.

904.7.2 Unlisted Components. Pressure containing components made of listed materials but not made in accordance with a specification or standard listed in Table 926.1 or Mandatory Appendix I shall be substantiated by at least one of the following:

- (a) engineering calculations
- (b) experimental stress analysis such as described in Part 5 in Section VIII, Division 2 of the ASME BPV Code
- (c) proof test in accordance with UG-101 in Section VIII, Division 1 of the ASME BPV Code

If differences in size and proportion are small, components may be designed by interpolation between similar configurations that have been proven by one of the procedures described above, or that conform to a listed standard.

PART 3 SELECTION AND LIMITATION OF COMPONENTS

905 PIPE

905.1 General

905.1.1 Listed Pipe. Pipe manufactured in accordance with a specification or standard listed in Table 926.1 or Mandatory Appendix I, as qualified by the Notes, may be used in accordance with its ratings or allowable stresses, within other limitations in para. 905, and within the limitations on joints in Chapter II, Part 4 and on materials in Chapter III.

905.2 Specific Limitations

905.2.1 Cast Iron Pipe. Cast iron pipe shall not be used above ground in oil or other flammable liquid service, nor in compressed gas service.

905.2.2 Steel Pipe. Furnace butt weld steel pipe shall not be used for flammable or combustible liquids.

905.2.3 Copper Alloy Pipe and Tube. Copper pipe and tube shall not be used for flammable or combustible liquids except as permitted in para. 922.3.1(c).

905.2.4 Nonmetallic Pipe. Unlisted reinforced thermosetting resin pipe shall not be used.

905.2.5 Thermoplastics Pipe. See para. 923.3.2 for limitations on thermoplastics.

906 FITTINGS, BENDS, AND INTERSECTIONS

906.1 Fittings

906.1.1 Listed Fittings. Fittings manufactured in accordance with a specification or standard listed in Table 926.1 or Mandatory Appendix I may be used in accordance with their ratings or allowable stresses, within other limitations in para. 906, and within the limitations on joints in Chapter II, Part 4 and on materials in Chapter III.

906.2 Bends and Miter Joints

See para. 904.2.2(a) for service limitations on restricted miter joints.

906.3 Limitations on Fittings

Cast iron fittings shall not be used in flammable liquid or gas service. See para. 923.3.2 for limitations on thermoplastics.

907 VALVES

907.1 General

907.1.1 Listed Valves. Valves manufactured in accordance with a standard listed in Table 926.1 may be used in accordance with their ratings, within other limitations in para. 907, and within the limitations on joints in Chapter II, Part 4 and on materials in Chapter III.

907.1.2 Unlisted Valves. Valves not manufactured in accordance with a listed standard shall be used only within the manufacturer's recommendations as to service and ratings, and within the limitations on comparable listed valves, considering composition, mechanical properties, dimensions, method of manufacture, and quality control. Otherwise, the valves shall be qualified in accordance with para. 904.7.2.

907.2 Marking

Each valve shall bear markings in accordance with MSS SP-25, including the manufacturer's name or trademark, the material of construction, and symbols to indicate the service conditions for which the manufacturer rates the valve. Other markings shall be included if required by the applicable standard.

908 FLANGES, BLANKS, GASKETS, AND BOLTING

908.1 General

908.1.1 Listed Components. Flanges, blanks, gaskets, and bolting manufactured in accordance with a standard listed in Table 926.1 may be used in accordance with their ratings, within manufacturers' recommendations, within other limitations in para. 908, and within

the limitations on joints in Chapter II, Part 4 and on materials in Chapter III.

908.2 Flange Facings

Flange facings shall be in accordance with the standards listed in Table 926.1, or as provided in MSS SP-6. When bolting raised-face steel flanges to flat-face cast iron flanges, bolting torque should be limited to prevent cracking the cast iron flange; otherwise, steel flanges should be furnished with a flat-face, and full-face gaskets shall be used.

908.3 Gaskets

Material, thickness, and type of gasket shall be selected to suit the fluid to be handled and the design pressure and temperature.

908.4 Bolting

Bolts, nuts, and washers shall conform to applicable standards listed in Table 926.1.

PART 4 SELECTION AND LIMITATION OF JOINTS

910 PIPING JOINTS

The type of joint used shall be suitable for the design conditions and the fluid handled, and shall be selected with consideration of joint tightness and mechanical strength.

911 WELDED JOINTS

911.1 Metallic Pipe

Welded joints shall be used only for materials for which welding procedures, welders, and welding machine operators have been qualified as required in Chapter V.

911.1.1 Butt and Miter Welds. Butt and miter joint welds shall be made in accordance with para. 927.4.2, and shall be full penetration welds. (Backing rings are not recommended.)

911.1.2 Socket Welding. Socket welds shall be made in accordance with para. 911.1.3. In addition, dimensions of socket-type joints shall conform to those in standards listed in Table 926.1.

911.1.3 Fillet Welds. Fillet welds in properly designed connections shall be made in accordance with para. 927.4.3.

911.1.4 Seal Welds. Seal welds are intended only to provide leak tightness for threaded joints and are not considered to add strength to the joint.

911.2 Nonmetallic Pipe

911.2.1 Thermoplastic Welding. Welds in thermoplastic materials shall conform to the requirements in para. 934.1.3.

911.2.2 Thermoplastic Socket Welding. Dimensions of socket-type joints shall conform to those in standards for fittings listed in Table 926.1.

912 FLANGED JOINTS

Flanged joints shall meet the requirements in para. 908.

913 MECHANICAL AND PROPRIETARY JOINTS

Grooved, extruded, expanded, rolled, O-ring, clamp, gland-type, and other mechanical or proprietary joints may be used where experience or tests in accordance with para. 904.7 have demonstrated that the joint is safe for the operating conditions and the fluids being transported, and where adequate provision is made to prevent separation of the joint. All such joints shall be used within the manufacturer's limitations on pressure-temperature ratings and other recommendations for installation and use.

913.1 Limitations on Mechanical and Proprietary Joints

Joints dependent on friction characteristics or resiliency of combustible or low melting point materials for mechanical continuity or leak tightness shall not be used for flammable fluids or gases inside buildings.

914 THREADED JOINTS

Threaded joints may be used within the limitations on fittings in para. 906, limitations on materials in Chapter III, and other limitations herein.

914.1 Acceptable Types

Threads on pipe and fittings shall be tapered pipe threads in accordance with ASME B1.20.1 or other applicable standards listed in Table 926.1, except that threads in wrought steel couplings NPS 2 (DN 50) and smaller may be straight pipe threads. Threads other than tapered pipe threads may be used where tightness of the joint depends on a seal weld or seating surface other than the threads, and where experience or test has demonstrated that such threads are suitable.

914.2 Limitations on Threaded Joints

(a) Threaded joints shall not be used where severe erosion, crevice corrosion, shock, or vibration are expected to occur.

(b) Metallic pipe with a wall thickness less than that of standard wall in ASME B36.10M shall not be threaded, regardless of service.

(c) Plastic pipe with wall thickness less than that of Schedule 80 shall not be threaded.

(d) Polyethylene pipe and polybutylene pipe shall not be threaded.

915 FLARED, FLARELESS, AND COMPRESSION JOINTS

Flared, flareless, and compression-type tubing fittings and joints may be used within the limitations of applicable standards listed in Table 926.1, on materials in Chapter III, and other limitations herein.

Fittings and joints shall be compatible with the tubing with which they are used, and shall be used within the manufacturer's pressure-temperature ratings. Vibration and thermal cycling shall be considered in each application.

916 BELL AND SPIGOT JOINTS

916.1 Caulked or Leaded Joints

Bell and spigot joints, caulked with lead and packing material, may be used only for water service up to 100°F (38°C), where adequate provision is made to prevent separation of the joints. See ANSI/AWWA C600 for joints in cast iron pressure piping.

916.2 Push-Type Elastomer Gasket

Push-type joints with elastomer gaskets may be used where experience or tests have demonstrated that the joint is safe for the operating conditions and the fluid being transported, and where adequate provision is made to prevent separation of the joints.

917 BRAZED AND SOLDERED JOINTS

917.1 General

Brazed and soldered socket-type joints shall be made in accordance with para. 928 and with brazing or soldering filler metals that are compatible with the base material and with the pressure, temperature, and other service conditions.

917.2 Brazed Joints

Socket-type brazed joints may be used within the limitations on materials in Chapter III.

917.3 Soldered Joints

917.3.1 General. Soldered socket-type joints may be used within the pressure-temperature limitations in Table 917.3. Soldered joints other than socket-type shall not be used.

Table 917.3 Rated Internal Working Pressures of Joints Made With Copper Water Tube and Solder Joint Fittings, psig

Solder or Brazing Alloy Used in Joints	Maximum Service Temperature, °F	Types K, L, M Copper Water Tube in Nominal Sizes, in.					Saturated Steam and Condensate, All Sizes
		Liquids and Gases [Note (1)]					
		1/4–1	1 1/4–2	2 1/2–4	5–8 [Note (2)]	10–12 [Note (2)]	
50-50 Tin-Lead ASTM B32 Gr 50A	100	200	175	150	135	100	...
	150	150	125	100	90	70	...
	200 [Note (2)]	100	90	75	70	50	...
	250 [Note (2)]	85	75	50	45	40	15
95-5 Tin-Antimony ASTM B32 Gr 95TA	100	500	400	300	270	150	...
	150	400	350	275	250	150	...
	200 [Note (2)]	300	250	200	180	140	...
	250 [Note (2)]	200	175	150	135	110	15
Brazing Alloys	200 [Note (2)]	[Note (3)]	[Note (3)]	[Note (3)]	[Note (3)]	[Note (3)]	...
	250 [Note (2)]	300	210	170	150	150	15
	350 [Note (2)]	270	190	150	150	150	120

NOTES:

(1) See limitations in para. 917.3.2.

(2) See paras. 900.1.2(d) and (e) for pressure and temperature limits under this Code.

(3) Rated pressure for temperatures up to 200°F is that of the tube being joined.

917.3.2 Limitations. Soldered joints shall not be used for flammable or toxic gases or liquids. They shall not be used for compressed air or other gases in tubing over 4.125 in. (105 mm) O.D. unless the maximum pressure is limited to 20 psig (138 kPa).

PART 5**EXPANSION, FLEXIBILITY, AND SUPPORT****919 EXPANSION AND FLEXIBILITY****919.1 General**

In addition to design requirements for pressure, weight, and other loadings, piping systems subject to thermal expansion or contraction, or to similar movements imposed by other sources shall be designed to prevent

- (a) failure of piping or supports from overstress or fatigue
- (b) leakage of joints
- (c) detrimental stresses or distortion in connected equipment (pumps, turbines, valves, etc.) resulting from excessive thrusts and moments

919.2 Concepts

919.2.1 General. The treatment of flexibility analysis in this Code covers only the simplest applications. For piping systems not compatible with this simplified approach, the user is directed to Chapter II, Part 5 of ASME B31.1. The concepts, methods, and requirements therein are acceptable under this Code.

919.2.2 Means of Providing Flexibility. Flexibility may be increased by one or more of the following means:

- (a) adding elbows, bends, or loops where feasible
- (b) installing expansion joints, properly guided and restrained
- (c) installing rotary joints, properly guided and restrained

919.2.3 Flexibility in Nonmetallic Piping. Particular care must be taken in selecting the methods given in para. 919.2.2 when laying out nonmetallic piping systems, because they are difficult or impossible to analyze, have very limited capacity for overstress, are subject to brittle failure, and may have high coefficients of thermal expansion and nonlinear stress-strain characteristics.

919.3 Properties for Analysis**919.3.1 Coefficients of Thermal Expansion.**

Table 919.3.1 contains data on thermal expansion characteristics of many of the metallic and nonmetallic materials used in this Code.

919.4 Analysis, Metallic Piping**919.4.1 Requirements for Analysis**

(a) *Simplified Analysis.* No formal analysis is required for systems that meet one of the following criteria:

- (1) The system duplicates a successfully operating installation or replaces a system with a satisfactory service record.

(14) **Table 919.3.1 Moduli of Elasticity and Thermal Expansion Coefficients**

Material	Modulus of Elasticity, psi $\times 10^6$	Coefficient of Thermal Expansion, in./in., $^{\circ}\text{F} \times 10^{-6}$ [Note (1)]	Linear Thermal Expansion, in./100 ft, Between 70°F and Indicated Temperature, °F					
			0	25	50	70	100	125
Carbon steel	27.5	6.33	−0.49	−0.32	−0.14	0	0.23	0.42
Austenitic stainless steel	29.0	9.27	−0.72	−0.46	−0.21	0	0.34	0.62
Aluminum	10.0	12.69	−0.97	−0.63	−0.28	0	0.46	0.85
Gray cast iron	13.0	5.76	−0.49	−0.32	−0.14	0	0.21	0.38
Ductile iron	...	5.97	−0.46	−0.30	−0.14	0	0.21	0.39
Copper C12200 (99.9Cu)	17.0	9.50	−0.80	−0.51	−0.23	0	0.34	0.63
Copper CA 23000 (red brass) (85Cu)	17.0	10.40	−0.87	−0.56	−0.25	0	0.37	0.69
ABS 1210	0.25	55.0	...	...	−1.32	0	1.98	...
1316	0.34	40.0	...	...	−0.96	0	1.44	...
2112	...	40.0	...	...	−0.96	0	1.44	...
CPVC 4120	0.42	35.0	...	...	−0.84	0	1.26	2.31
PVC 1120	0.42	30.0	...	...	−0.72	0	1.08	...
1220	0.41	35.0	...	...	−0.84	0	1.26	...
2110	0.34	50.0	...	...	−1.20	0	1.80	...
2120	...	30.0	...	...	−0.72	0	1.08	...
PB 2110	...	72.0	...	...	−1.73	0	2.59	4.75
PE 2306	0.09	80.0	...	...	−1.92	0	2.88	...
2606	0.100	100.0	...	...	−2.40	0	3.60	...
2706	0.100	100.0	...	...	−2.40	0	3.60	...
2708	0.100	100.0	...	...	−2.40	0	3.60	...
3306	0.13	70.0	...	...	−1.68	0	2.52	...
3406	0.15	60.0	...	...	−1.44	0	2.16	...
3608	0.125	90.0	...	...	−2.16	0	3.24	...
3708	0.125	90.0	...	...	−2.16	0	3.24	...
3710	0.125	90.0	...	...	−2.16	0	3.24	...
4708	0.130	80.0	...	...	−1.92	0	2.88	...
4710	0.130	80.0	...	...	−1.92	0	2.88	...
PP 1110	...	48.0	...	...	−1.15	0	1.73	...
1208	...	43.0	...	...	−1.03	0	1.55	...
2105	...	40.0	...	...	−0.96	0	1.44	...
RTRP	Consult manufacturer							

NOTE:

(1) Average of the mean values over the temperature range for which data are shown.

Table 919.3.1 Moduli of Elasticity and Thermal Expansion Coefficients (Cont'd)

Linear Thermal Expansion, in./100 ft, Between 70°F and Indicated Temperature, °F										Material
150	175	200	225	250	275	300	325	350	375	
0.61	0.80	0.99	1.21	1.40	1.61	1.82	2.04	2.26	2.48	Carbon steel
0.90	1.18	1.46	1.75	2.03	2.32	2.61	2.90	3.20	3.50	Austenitic stainless steel
1.23	1.62	2.00	2.41	2.83	3.24	3.67	4.09	4.52	4.95	Aluminum
0.55	0.73	0.90	1.00	1.27	1.45	1.64	1.83	2.03	2.22	Gray cast iron
0.57	0.76	0.94	1.13	1.33	1.53	1.72	1.93	2.13	2.36	Ductile iron
0.91	1.20	1.48	1.77	2.05	2.34	2.62	2.91	3.19	...	Copper C12200 (99.9Cu)
1.00	1.31	1.62	1.93	2.25	2.56	2.87	3.18	3.49	...	Copper CA 23000 (red brass) (85Cu)
...	...	...	...	...	...	...	...	...	...	ABS 1210
...	...	...	...	...	...	...	...	...	...	1316
...	...	...	...	...	...	...	...	...	...	2112
3.36	4.41	...	...	...	...	...	...	...	...	CPVC 4120
...	...	...	...	...	...	...	...	...	...	PVC 1120
...	...	...	...	...	...	...	...	...	...	1220
...	...	...	...	...	...	...	...	...	...	2110
...	...	...	...	...	...	...	...	...	...	2120
6.91	9.07	...	...	...	...	...	...	...	...	PB 2110
...	...	...	...	...	...	...	...	...	...	PE 2306
...	...	...	...	...	...	...	...	...	...	2606
...	...	...	...	...	...	...	...	...	...	2706
...	...	...	...	...	...	...	...	...	...	2708
...	...	...	...	...	...	...	...	...	...	3306
...	...	...	...	...	...	...	...	...	...	3406
...	...	...	...	...	...	...	...	...	...	3608
...	...	...	...	...	...	...	...	...	...	3708
...	...	...	...	...	...	...	...	...	...	3710
...	...	...	...	...	...	...	...	...	...	4708
...	...	...	...	...	...	...	...	...	...	4710
...	...	...	...	...	...	...	...	...	...	PP 1110
...	...	...	...	...	...	...	...	...	...	1208
...	...	...	...	...	...	...	...	...	...	2105
										RTRP

(2) The system is of ductile material (e.g., there are no cast iron fittings); the segment being analyzed has no more than two anchors and no intermediate restraints; it has no more than two pipe sizes, differing by one standard size; the least nominal wall thickness is no less than 75% of the greatest; and thermal expansion in the segment satisfies eq. (8).

(U.S. Customary Units)

$$DY/(L - U)^2 \leq 0.03 \quad (8)$$

(SI Units)

$$DY/(L - U)^2 \leq 208.3$$

where

- D = the nominal size of the larger pipe in the segment
- L = developed length of line axis, ft (m)
- U = anchor distance (length of straight line joining)
- Y = resultant of movements to be absorbed by pipe lines, in. (mm)

NOTE: There is no assurance that eq. (8) is always accurate or conservative, especially for nearly straight sawtooth segments or for unequal leg U-bends. There is no assurance that end reactions will be acceptably low.

(3) The system is laid out with a conservative margin of inherent flexibility, or employs joining methods, expansion devices, or a combination of joining method and expansion devices in accordance with applicable manufacturers' instructions.

(b) *Other Methods of Analysis.* Piping systems that do not meet the criteria of 919.4.1(a) shall be analyzed by suitable approximate or conservative methods as outlined in ASME B31.1, paras. 119.7.1(C) and (D), and as directed elsewhere in para. 119 of ASME B31.1.

919.5 Movements

Movements caused by thermal expansion or contraction and other similar loadings shall be determined for consideration of obstructions and design of supports.

919.6 Cold Spring

Cold spring is the intentional displacement of piping during assembly. When applied, it is normally to compensate for one-half of the total expected pipe movement due to expansion. Possible benefits of cold spring include

- (a) reduced likelihood of overstrain during initial operation
- (b) reduced deviation from as-installed hanger positions
- (c) reduction of maximum end reactions

No credit for cold spring is permitted in stress range calculations.

919.7 Reactions

Terminal reactions and resulting moments shall be taken into consideration where supporting structure or

connected equipment is likely to be affected by such loadings. Determination of these loads may require analysis as specified in para. 919.4.1(b).

920 LOADS ON PIPE-SUPPORTING ELEMENTS

920.1 General

Supports, as used in this Code, include rigid hangers (that support the line from above without springs), spring hangers, supports that bear the load from below, and guides and anchors that limit pipe movement as well as support loads.

920.1.1 Loads on Supports. The loads to be considered in design of supports are

- (a) dead weight of pipe, fittings, valves, insulation, inline equipment, hanger system, and other pipelines (if supported from the line under consideration)
- (b) live weight of contents
- (c) weight of test fluid (see para. 920.2)
- (d) occasional loads, such as ice, wind, and earthquake

Weight of test fluid and occasional loads need not be considered concurrently.

920.1.2 Loads on Restraints

(a) *General.* In addition to the loads described in para. 920.1.1, anchors, guides, and other restraints shall be designed to bear loads resulting from thermal expansion and contraction and from other movements of the piping, such as those caused by internal pressure.

(b) *Expansion Joint Loads.* Use of expansion joints usually increases reactions at anchors. For corrugated and slip joints, in the absence of manufacturer's data, anchor reaction may be calculated as the sum of

- (1) operating pressure times area corresponding to the maximum inside diameter of the joint corrugations
- (2) the force required to cause full rated deflection of the joint
- (3) frictional forces at guides and supports

If the expansion joint is at an elbow or bend, the vector forces due to fluid change in direction must also be included.

920.1.3 Other Loads. Loads from other design conditions described in para. 901 shall be considered in design of both supports and restraints. Loads due to shock and vibration should preferably be minimized by the use of suitable dampeners or properly placed supports and restraints.

920.2 Test Loads

920.2.1 Test Loads on Rigid Supports. Rigid supports shall be capable of bearing the total load under test conditions as well as those of normal operation, unless additional supports are provided during testing.

920.2.2 Test Loads on Spring Hangers. Load conditions for calculated operation of spring hangers should not take test loads into account. The hanger assembly, however, shall be capable of supporting the test load unless additional supports are provided during testing.

921 DESIGN OF PIPE-SUPPORTING ELEMENTS

921.1 General

Pipe-supporting elements shall be designed to carry the sum of all concurrently acting loads described in para. 920. Unless designed to anchor or restrain line movements by withstanding the resultant forces and moments, they shall permit free movement of the piping resulting from thermal expansion or other causes.

In addition, supports shall be so located and spaced as to protect the supported piping from excessive stress and distortion.

921.1.1 Materials and Stresses. Except as permitted herein, materials for pipe-supporting elements shall be listed in Mandatory Appendix I. Allowable stresses for pipe-supporting elements shall be one-fourth of the minimum tensile strength shown in Mandatory Appendix I. For carbon steel of unknown specification, the allowable stress shall not exceed 9,500 psi (65.5 MPa).

(a) *Threaded Parts.* The maximum safe loads shall be calculated on the root area of the threads of threaded parts.

(b) *Allowable Overstress.* An increase in allowable stress is permitted up to 80% of specified minimum yield strength during hydrostatic testing, not to exceed 24,000 psi (165.5 MPa) for carbon steel of unknown specification.

(c) *Selection of Material.* Hanger and support materials shall be compatible with the characteristics of the piping materials, so that neither shall adversely affect the other.

921.1.2 Hanger Adjustments. Hangers supporting piping NPS 2½ (DN 65) and larger shall be designed to permit adjustment after erection while supporting the load. Threaded parts for adjustment shall be in accordance with ASME B1.1.

Turnbuckles and adjusting nuts shall have full thread engagement. Threaded adjustments shall be provided with suitable locking devices.

921.1.3 Support Spacing

(a) *Piping Stresses.* Stresses in the piping due to support spacing shall not exceed the basic allowable stress S when computed on the basis of a support span twice as great as the actual span.

(b) *Allowable Deflection.* The allowable deflection of the pipe between supports shall not exceed the smaller of 0.25 in. (6.4 mm) or 15% of the outside diameter of the pipe, based on the weight of the pipe, service fluid (S.G. ≤ 1.0), and insulation.

(c) *Spacing, Steel Pipe.* Figure 921.1.3-1 shows the maximum recommended support spacing for standard weight Grade A, Grade B, and Schedule 10 pipe.

(d) *Spacing, Other Materials.* The maximum recommended support spacing for copper and plastic pipe is shown in Fig. 921.1.3-2.

(e) *Limitations on Charts.* The spans in Figs. 921.1.3-1 and 921.1.3-2 are based on limitations in paras. 921.1.3(a) and (b) and are not applicable where there are concentrated loads, i.e., valves, special fittings, etc. Spans and deflections are based on the simple beam formulas limiting the combined pressure and bending stress to the basic allowable stress for the material.

921.1.4 Springs. Springs used in spring hangers shall be designed and manufactured in accordance with MSS SP-58.

921.2 Fixtures

921.2.1 Anchors and Guides

(a) *Requirements.* Anchors, guides, pivots, and other restraints shall be designed to secure the piping at their respective locations against movement in specified planes or directions, while permitting free movement elsewhere. They shall be structurally suitable to withstand the thrusts, moments, and other imposed loads.

(b) *Required Guides.* Where bellows or slip-type expansion joints are used, anchors and guides shall be provided to direct expansion movement along the axis of the joint.

(c) *Pipe Buckling.* The column buckling strength of the pipe must be taken into consideration when determining guide spacing for expansion joints. This is especially true for small diameter lines. Maximum spacing of guides for any pipe material or thickness may be calculated using eq. (9).

(U.S. Customary Units)

$$L_S = 0.131 \sqrt{E_m I / (PB + Q)} \quad (9)$$

(SI Units)

$$L_S = 0.00157 \sqrt{E_m I / (PB + Q)}$$

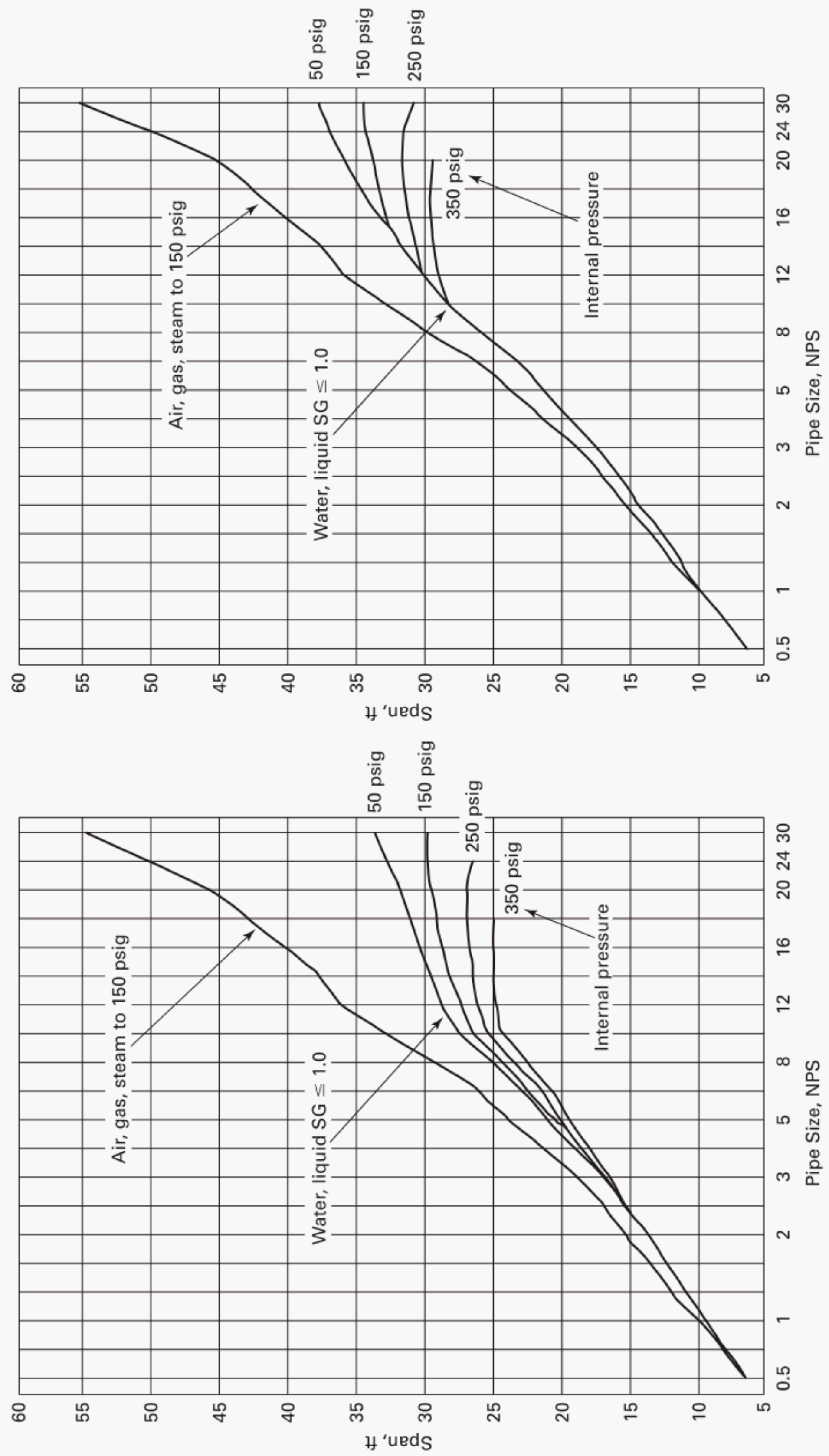
Q is positive for expansion joint compression and negative for expansion joint extension.

(d) *Rolling or Sliding Supports.* These supports shall permit free movement of the piping, or the piping shall be designed to include the imposed loads and friction forces of the supports. Materials and lubricants used in sliding supports shall be suitable for the metal temperature at the point of contact.

921.2.2 Other Rigid Supports

(a) *Hanger Rods.* Safe loads for hanger rods shall be based on the root area of threads and allowable stress for the material. In no case shall hanger rods less than ⅜ in. (9.5 mm) in diameter be used to support pipe

Fig. 921.1.3-1 Support Spans for Standard Wall Steel Pipe



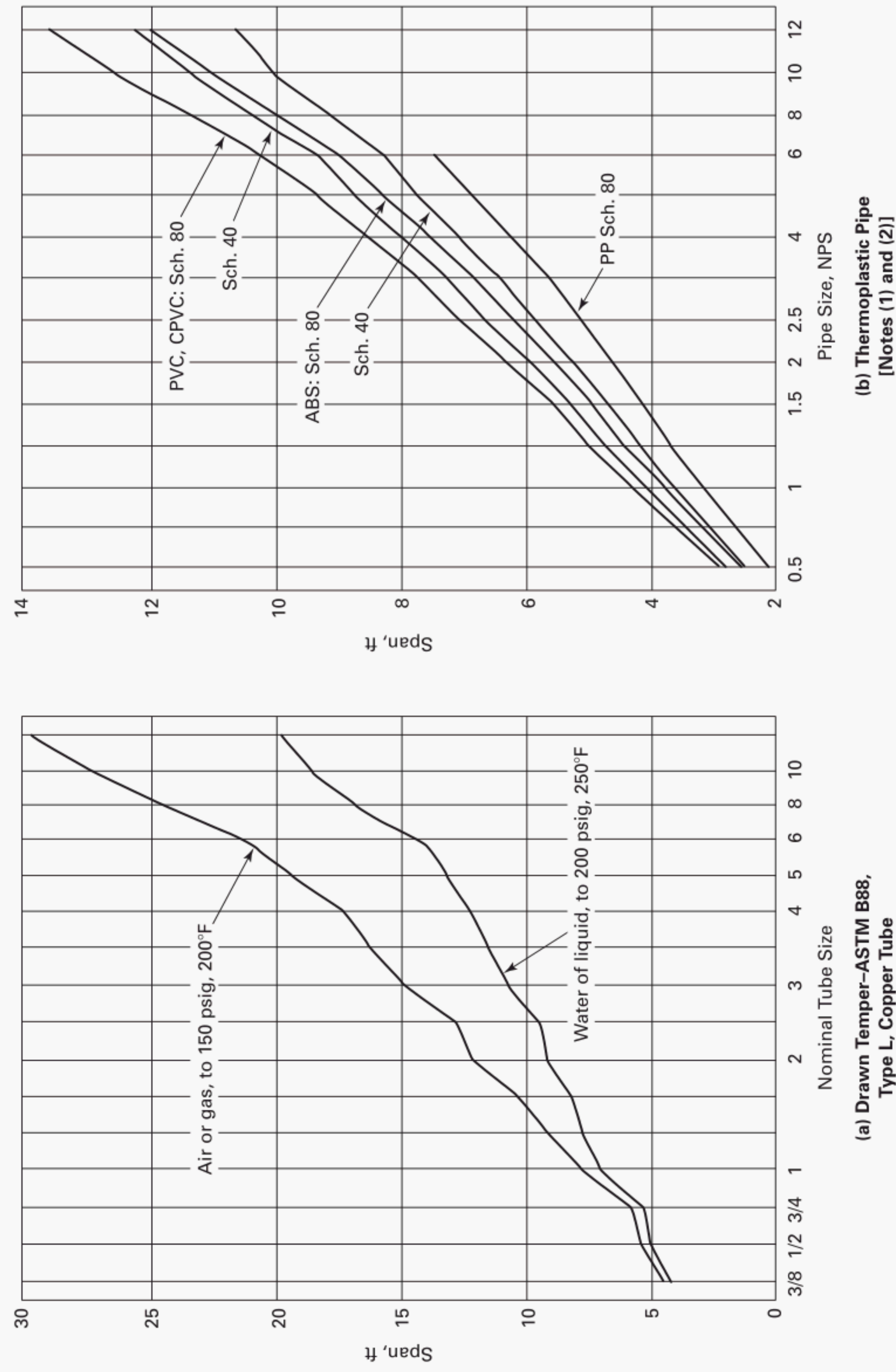
(a) Basic Allowable Stress = 12,000 psi
Grade A
[Notes (1) and (2)]

(b) Basic Allowable Stress = 15,000 psi
Grade B
[Notes (3) and (4)]

NOTES:

- (1) For Grade A pipe threaded to NPS 2 and welded above NPS 2.
- (2) Use for grooved pipe.
- (3) For Grade B pipe threaded to NPS 2 and welded above NPS 2.
- (4) Use 12,000 psi chart for grooved joints.

Fig. 921.1.3-2 Support Spans for Copper and Thermoplastic Pipe



NOTES:

(1) Based on pipe at 73°F with water and insulation. Closer spacing required at higher temperatures.

(2) Use shields on all hangers to avoid point loading of pipe.

Table 921.2.2 Capacities of Threaded ASTM A36 Steel Rods

Nominal Rod Diameter, in.	Root Area of Coarse Thread, in. ²	Maximum Safe Load, lb (S = 11.6 ksi)
1/4	0.027	310
3/8	0.068	790
1/2	0.126	1,460
5/8	0.202	2,340
3/4	0.302	3,500
7/8	0.419	4,860
1	0.552	6,400
1 1/8	0.693	8,000
1 1/4	0.889	10,300

NPS 1 1/2 (DN 40) or larger. See Table 921.2.2 for permissible loads on carbon steel rods.

Pipe, straps, or bars of strength and effective area equivalent to hanger rod may also be used.

(b) *Cast Iron.* ASTM A48 cast iron may be used for bases, rollers, anchors, and parts of supports where the loading is primarily in compression. Cast iron parts shall not be used in tension.

(c) *Malleable Iron.* ASTM A47 malleable iron may be used for pipe clamps, beam clamps, hanger flanges, clips, bases, swivel rings, and parts of pipe supports.

921.2.3 Variable Supports

(a) *Requirements.* Variable spring supports shall be designed to exert a supporting force equal to the load, as determined by weight balance calculations, plus the weight of all hanger parts (such as clamp, rod, etc.) that will be supported by the spring at the point of attachment to the pipe.

(b) *Design.* Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, and overstressing of the spring. It is recommended that they be designed for a maximum variation in supporting effort of 25% for the total travel resulting from thermal movement.

(c) *Indicators.* It is recommended that all hangers employing springs be provided with means to indicate at all times the compression of the spring with respect to the approximate hot and cold positions of the pipe system, except where they are used either to cushion against shock or where the operating temperature of the system does not exceed 250°F (121°C).

921.3 Structural Attachments

921.3.1 Nonintegral Type. Nonintegral attachments include clamps, slings, cradles, saddles, straps, and clevises.

When clamps are used to support vertical lines, they shall be designed to support the total load due to weight of piping, contained fluid, insulation, and other loads such as forces from expansion joints. It is recommended

that shear lugs or the clamp be welded to the pipe to prevent slippage, following the requirements of para. 921.3.2.

921.3.2 Integral Type. Integral attachments include ears, shoes, lugs, cylindrical attachments, rings, and skirts fabricated so as to be an integral part of the piping. When welded to the pipe, materials and procedure shall be compatible with the piping and strength shall be adequate for all expected loadings. If piping and support materials differ in allowable stress, the lower shall govern design.

Integral attachments shall be used in conjunction with restraints or braces where multiaxial loadings are imposed. Design shall consider all imposed weight and thermal loadings, and shall minimize localized stresses induced in the piping by the attachment.

921.4 Supplemental Steel

Where it is required to frame structural members between existing steel members, such supplementary steel shall be designed using the allowable stress specified in para. 921.1.1.

921.5 Attachments to Concrete

921.5.1 Maximum Loads on Attachments. Loads on anchors, cast-in-place inserts, and other attachments to concrete shall not exceed one-fifth of the ultimate strength of the attachment as determined by manufacturer's tests in concrete of compressive strength not greater than that in which the attachment will be used, but at least 2,500 psi (17.2 MPa).

If the compressive strength of the concrete is unknown, it shall be assumed to be 2,500 psi (17.2 MPa) and the manufacturer's rated load for the fastener shall be reduced in the ratio of 2,500 psi (17.2 MPa) to the strength used in the tests to determine the rating.

In the absence of manufacturer's ratings, the attachment may be tested for ultimate strength in accordance with ASTM E488.

921.5.2 Expansion Studs and Anchors. Mechanically attached concrete or masonry anchors shall extend into the concrete at least the minimum distance recommended by the manufacturer; use a length at least 4 1/2 times the fastener diameter in the absence of such recommendation.

If multiple anchors are required to hold a load, they must be spaced at least eight diameters on center to realize the full design capacity of each anchor.

921.5.3 Concrete Inserts. Placing of inserts shall be in accordance with the manufacturer's recommendations.

921.5.4 Explosive Actuated Fasteners. Explosive actuated fasteners shall not be used where a group of fasteners is necessary to support the total load.

921.5.5 Split Pin Compression Anchors. Split pin compression anchors shall be used only for shear loads.

921.6 Supporting Structures

The engineer shall assure himself that the supporting structure has adequate strength to sustain all loads imposed by the piping.

PART 6 SYSTEMS

922 DESIGN REQUIREMENTS PERTAINING TO SPECIFIC PIPING SYSTEMS

922.1 Pressure Reducing Systems

- (14) **922.1.1 General.** Where pressure reducing valves are used, a relief device or safety valve shall be provided on the low-pressure side of the system. Otherwise, the piping and equipment on the low side of the system shall be designed to withstand the upstream design pressure. The relief or safety devices shall be located adjoining or as close as practicable to the reducing valve. The combined relieving capacity provided shall be such that the design pressure of the low-pressure system will not be exceeded if the reducing valve fails in the open position.

- (14) **922.1.2 Alternative Systems.** In steam systems where the use of relief valves as described in para. 922.1.1 is not feasible (e.g., because there is no acceptable discharge location for the vent piping), alternative designs may be substituted for the relief devices. In either case, it is recommended that alarms be provided that will reliably warn the operator of failure of any pressure reducing valve.

(a) *Tandem Steam Pressure Reducing Valves.* Two or more steam pressure reducing valves may be installed in series, each set at or below the safe working pressure of the equipment served. In this case, no relief device is required.

Each pressure reducing valve shall have the capability of closing off against full line pressure, and of controlling the reduced pressure at or below the design pressure of the low-pressure system, in the event that the other valve fails in the open position.

(b) *Trip Stop Valves.* A trip stop steam valve set to close at or below the design pressure of the low-pressure system may be used in place of a second reducing valve or a relief valve.

922.1.3 Bypass Valves. Hand-controlled bypass valves having a capacity no greater than the reducing valve may be installed around pressure reducing valves

if the downstream piping is protected by relief valves as required in para. 922.1.1, or if the design pressure of the downstream piping system and equipment is at least as high as the upstream pressure.

922.1.4 Design of Valves and Relief Devices. Pressure reducing and bypass valves, and relief devices, shall be designed for inlet pressure and temperature conditions.

922.2 Steam Trap Piping

922.2.1 Drip Lines. Drip lines from steam headers, mains, separators, heaters, or other equipment that operate at differing pressures shall not be connected to discharge through the same trap.

922.2.2 Discharge Piping. Trap discharge piping shall be designed for the same pressure and temperature as the inlet piping unless the discharge is vented to atmosphere, or is operated under low pressure and has no stop valves.

922.3 Fuel Oil Piping

922.3.1 Pipe Material

(a) Pipe in buildings shall be steel pipe of a material listed in Table 926.1 except as permitted in para. 922.3.1(b). Type F furnace butt welded pipe shall not be used where concealed, e.g., in walls, chases, shafts, or above ceilings. Spiral welded pipe shall not be used.

(b) Type L copper tubing may be used in buildings if protected from exposure to fire.

(c) Underground piping may be steel, Type K copper tubing, aluminum, ductile iron, thermoplastic, or reinforced thermoplastic resin piping. Buried pipe and fittings shall be protected against corrosion.

922.3.2 Joints

(a) Threaded, welded, brazed, or flared joints shall be used within buildings. A pipe thread compound suitable for oil shall be used on threaded joints. Joints relying on friction or a combustible material shall not be used. Brazing or flare fittings shall be wrought. Flanged or grooved joints may be used with a gasket material meeting the requirements of API 607 or another standard acceptable to the owner.

(b) For underground piping, friction-type joints and grooved joints may also be used.

922.3.3 Valves. At the point of entry of underground piping to the building, an accessible steel or ductile iron valve shall be installed to control the flow of oil.

Chapter III Materials

923 MATERIALS — GENERAL REQUIREMENTS

Chapter III states limitations for materials, based on their inherent properties. Their use in piping is also subject to requirements and limitations in other parts of this Code.

923.1 Materials and Specifications

923.1.1 Listed or Published Specifications. Any material used in pressure containing piping components shall conform to a specification listed in Mandatory Appendix I, or to a published specification in accordance with para. 923.1.2.

923.1.2 Materials Not Listed. Allowable stresses for materials not shown in Mandatory Appendix I, but which are shown in ASME B31.1, may be taken from Mandatory Appendix A of ASME B31.1.

A material not listed in this Code nor in ASME B31.1, but which conforms to a published specification covering composition, physical and mechanical properties, method and process of manufacture, heat treatment (if applicable), and quality control may be used if it otherwise meets the requirements of this Code. Allowable stresses for such materials shall be determined in accordance with the applicable basis in para. 902.3.1, or a more conservative basis. Particular attention should be given to properties that may affect weldability or ductility adversely.

923.1.3 Used Materials. Used pipe and other components of known specifications may be employed provided they have been thoroughly cleaned and visually inspected (and tested if applicable) to determine that they are in good condition, meet the applicable dimensional requirements, and do not contain defects that could impair strength or tightness or that are not acceptable under this Code.

923.1.4 Limitations on Unknown Materials. Steel of unknown specification shall be used only for structural supports and restraints.

923.2 Limitations on Specific Metals

923.2.1 Cast Iron. The low ductility of cast iron should be considered and its use should be avoided where shock loading may occur.

923.2.2 Ductile Iron. Ductile (nodular) cast iron components having dimensions conforming to

ASME B16.3, ASME B16.4, or ASME B16.5 may be used in accordance with the manufacturer's pressure-temperature ratings. Welding shall not be used as a method of joining ductile iron components.

923.2.3 Copper and Copper Alloys. Consideration should be given to the melting point of copper in flammable fluid service.

923.2.4 Aluminum and Aluminum Alloys. Consideration should be given to the melting point of aluminum in flammable fluid service. When assembling threaded joints in aluminum alloys, a suitable thread compound shall be used to prevent seizing. Pipe in the annealed temper should not be threaded.

923.3 Limitations on Specific Nonmetals

923.3.1 General. Nonmetallic pressure containing components, such as glass, ceramics, plastics, or rubber, may be used within the limitations of para. 923.1.2 and within manufacturers' limitations on pressure-temperature ratings and application. Consideration shall be given to the suitability of the material for the service conditions and the fluid to be handled, its flammability, resistance to shock, its dimensional stability, and proper support and protection from damage.

923.3.2 Thermoplastics. Thermoplastics shall not be used for toxic fluids or oxygen. They shall not be used for flammable liquids or flammable gases above ground. If thermoplastics are used for compressed air or other compressed gases, special precautions must be observed. The stored energy and specific failure mechanism of the pipe need to be considered. Materials such as PVC, CPVC, and PVDF, which exhibit brittle failure as defined in ASTM F412, shall not be used for compressed air or gas service.

Consideration shall be given to the brittleness and flammability of thermoplastics and to their loss of strength under only slight increases in temperature. In selecting thermoplastics, note that design properties are subject to considerable variation from one type and grade to another.

923.3.3 Reinforced Thermosetting Resin. In selecting reinforced thermosetting resin (RTR) piping, note that design properties are subject to considerable variation from one type and grade to another. Consideration shall be given to the flammability of RTR piping and its susceptibility to brittle failure.

923.3.4 Composite Materials. Composite materials shall be selected to conform to ASTM and manufacturer's recommendation for pressure-temperature, support, and service conditions.

923.4 Coatings and Linings

External coatings or internal linings may be used on pipe or components that conform to the requirements

of this Code, but such coatings or linings shall not be considered as adding strength.

923.5 Deterioration in Service

It is the responsibility of the engineer to select materials that will resist deterioration in service, or to make allowances for such deterioration in accordance with para. 902.4.1.

Chapter IV

Component Requirements and Standard Practices

926 DIMENSIONS AND RATINGS OF COMPONENTS

926.1 Standard Piping Components

Standard piping components shall conform to one of the standards or specifications listed in Table 926.1. Those listed in ASME B31.1 may also be used.

926.1.1 Boiler External Piping. Materials used in boiler external piping shall be ASME SA or SB specifications corresponding to the ASTM specifications listed in Table 926.1.

926.2 Standard Practices

The standards listed in Table 926.2 should be used for design and installation where applicable under this Code.

926.3 Nonstandard Piping Components

When nonstandard piping components are used, pressure design shall be in accordance with para. 904. Adherence to the dimensional principles in American National Standards referenced in Table 926.1 is recommended to the greatest practicable extent.

926.4 Abbreviations

Abbreviations used in Tables 926.1 and 926.2 signify the following:

Abbreviation	Term
	<u>General</u>
BW	butt-welding
CI	cast iron
DI	ductile iron
HT	high temperature
LT	low temperature
MI	malleable iron
SS	stainless steel
SW	socket-welding
Thd	threaded
TS	tensile strength
	<u>Plastics</u>
ABS	acrylonitrile-butadiene-styrene
CPVC	chlorinated polyvinyl chloride
PB	polybutylene
PE	polyethylene
PEX	crosslinked polyethylene
PP	polypropylene
PR	pressure rating
PVC	polyvinyl chloride
RTP	reinforced thermosetting plastic
RTR	reinforced thermosetting resin
SDR	standard dimension ratio
	<u>Composites</u>
PE-AL-PE	polyethylene-aluminum-polyethylene
PEX-AL-PEX	crosslinked polyethylene-aluminum-crosslinked polyethylene

Table 926.1 Component Standards and Specifications**(14)**

Component	Designation
Metallic Pipe, Fittings, Valves, and Flanges	
American Petroleum Institute (API)	
Line Pipe	5L
Wafer Check Valves	594
Butterfly Valves, Lug-Type and Wafer-Type	609
The American Society of Mechanical Engineers (ASME)	
Cast Iron Pipe Flanges and Flanged Fittings	B16.1
Malleable Iron Threaded Fittings, Classes 150 and 300	B16.3
Cast Iron Threaded Fittings, Classes 125 and 250	B16.4
Pipe Flanges and Flanged Fittings	B16.5
Factory-Made Wrought Steel BW Fittings	B16.9
Face-to-Face and End-to-End Dimensions of Ferrous Valves	B16.10
Forged Steel Fittings, Socket-Welding and Threaded	B16.11
Ferrous Pipe Plugs, Bushings, and Locknuts With Pipe Threads	B16.14
Cast Bronze Threaded Fittings, Classes 125 and 250	B16.15
Cast Copper Alloy Solder Joint Pressure Fittings	B16.18
Wrought Copper and Copper Alloy Solder Joint Pressure Fittings	B16.22
Bronze Pipe Flanges and Flanged Fittings, Classes 150 and 300	B16.24
Cast Copper Alloy Fittings for Flared Copper Tubes	B16.26
Wrought Steel Buttwelding Short Radius Elbows and Returns	B16.28
Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psig (Sizes 1/2 Through 2)	B16.33
Valves, Flanged, Threaded, and Welding End	B16.34
Orifice Flanges	B16.36
Malleable Iron Threaded Pipe Unions, Classes 150, 250, and 300	B16.39
Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300	B16.42
Welded and Seamless Wrought Steel Pipe	B36.10M
Stainless Steel Pipe	B36.19M
Guidelines for Pressure Boundary Bolted Flange Joint Assembly	PCC-1
Society of Automotive Engineers (SAE)	
Refrigeration Tube Fittings	J513
American Society for Testing and Materials (ASTM)	
Ferritic Malleable Iron Castings	A47
Gray Iron Castings	A48
Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless	A53
Forgings, Carbon Steel, for Piping Components	A105
Seamless Carbon Steel Pipe for HT Service	A106
Gray Iron Castings for Valves, Flanges, and Pipe Fittings	A126
Electric-Resistance-Welded Steel Pipe	A135
Forgings, Carbon Steel for General Purpose Piping	A181/A181M
Cupola Malleable Iron	A197
Spiral-Welded Steel or Iron Pipe	A211
Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures	A234/A 234M
Copper Brazed Steel Tubing	A254
Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650°F (345°C)	A278/A278M
Seamless and Welded Austenitic Stainless Steel Pipes	A312/A312M
Ductile Iron Pressure Pipe	A377
Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures	A395/A395M
Wrought Austenitic SS Piping Fittings	A403/A403M
Ductile Iron Castings	A536

Table 926.1 Component Standards and Specifications (Cont'd)

Component	Designation
Metallic Pipe, Fittings, Valves, and Flanges (Cont'd)	
American Society for Testing and Materials (ASTM) (Cont'd)	
Electric-Resistance-Welded Coiled Steel Tubing for Gas and Fuel Oil Lines	A539
Aluminum-Alloy Sand Castings	B26/B26M
Seamless Copper Pipe, Standard Sizes	B42
Seamless Red Brass Pipe, Standard Sizes	B43
Steam or Valve Bronze Castings.	B61
Composition Bronze or Ounce Metal Castings.	B62
Seamless Copper Tube, Bright Annealed	B68/B68M
Seamless Copper Tube.	B75/B75M
Seamless Copper Water Tube	B88/B88M
Seamless Brass Tube [Note (1)].	B135/B135M
Aluminum-Alloy Drawn Seamless Tubes	B210/B210M
Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube	B241/B241M
Aluminum and Aluminum-Alloy Die, Hand, and Rolled Ring Forgings.	B247/B247M
General Requirements for Wrought Seamless Copper and Copper-Alloy Tube	B251/B251M
Seamless Copper Tube for Air Conditioning and Refrigeration Field Service	B280
Copper and Copper-Alloy Die Forgings (Hot-Pressed)	B283
Threadless Copper Pipe	B302
Factory-Made Wrought Aluminum and Aluminum-Alloy Welding Fittings.	B361
Aluminum-Alloy Formed and Arc Welded Round Tube.	B547
American Water Works Association (AWWA or ANSI/AWWA)	
Ductile Iron and Gray-Iron Fittings, 3 in. Through 48 in., for Water and Other Liquids	C110/A21.10
Ductile Iron Pipe Centrifugally Cast in Metal Molds or Sand-Lines Molds, for Water and Other Liquids	C151/A21.51
Steel Pipe Flanges for Waterworks Service — Sizes 4 in. Through 144 in.	C207
Dimensions for Fabricated Steel Water Pipe Fittings.	C208
Gate Valves for Water and Sewage Systems.	C500
Grooved and Shouldered Type Joints	C606
Federal Government	
Pipe, Cast Iron and Ductile Iron (Pressure, for Water and Other Liquids)	FS WW-P-421
Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)	
Class 150 Corrosion Resistant Gate, Globe, Angle, and Check Valves With Flanged and Butt Weld Ends	SP-42
Wrought Stainless Steel Butt Weld Fittings	SP-43
By-Pass and Drain Connection Standard	SP-45
Class 150 LW Corrosion Resistant Cast Flanges and Flanged Fittings.	SP-51
Butterfly Valves	SP-67
Cast Iron Gate Valves, Flanged and Threaded Ends	SP-70
Cast Iron Swing Check Valves, Flanged and Threaded Ends.	SP-71
Ball Valves With Flanged or Butt Weld Ends for General Service.	SP-72
Cast Iron Plug Valves, Flanged and Threaded Ends	SP-78
Socket Welding Reducer Inserts.	SP-79
Bronze Gate, Angle, and Check Valves	SP-80
Carbon Steel Pipe Unions — Socket Welding and Threaded.	SP-83
Cast Iron Globe and Angle Valves, Flanged and Threaded Ends	SP-85
Diaphragm Type Valves	SP-88
Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends [Note (2)].	SP-110

Table 926.1 Component Standards and Specifications (Cont'd)

Component	Designation
Nonmetallic Pipe, Composite Pipe, Fittings, Valves, and Flanges	
American Society for Testing and Materials (ASTM)	
Reinforced Concrete Low-Head Pressure Pipe	C361/C361M
Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminants for Corrosion Resistant Equipment	C582
ABS Plastic Pipe, Schedules 40 and 80	D1527
PVC Plastic Pipe, Schedules 40, 80, and 120	D1785
PE Plastic Pipe, Schedule 40	D2104
PE Plastic Pipe (SDR-PR) Based on Controlled Inside Diameter	D2239
PVC Pressure Rated Pipe (SDR Series)	D2241
ABS Plastic Pipe (SDR-PR)	D2282
Classification for Machine-Made RTR Pipe	D2310
PE Plastic Pipe, Schedules 40 and 80 Based on Outside Diameter	D2447
Threaded PVC Plastic Pipe Fittings, Schedule 80	D2464
PVC Plastic Pipe Fittings, Schedule 40	D2466
Socket-Type PVC Plastic Pipe Fittings, Schedule 80	D2467
ABS Plastic Pipe Fittings, Schedule 40	D2468
Thermoplastic Gas Pressure Pipe Tubing and Fittings	D2513
Reinforced Epoxy Resin Piping Gas Pressure Pipe and Fittings	D2517
Plastic Insert Fittings for PE Plastic Pipe	D2609
Joints for IPS PVC Using Solvent Cement	D2672
Socket-Type PE Fittings for Outside Diameter-Controlled PE Pipe and Tubing	B2683
PE Plastic Tubing	D2737
CPVC Plastic Hot- and Cold-Water Distribution Systems	D2846
Filament-Wound RTR Pipe	D2996
Centrifugally Cast Glass Fiber RTR Pipe	D2997
PE Plastic Pipe (SDR-PR), Based on Controlled Outside Diameter	D3035
Butt Heat Fusion PE Plastic Fittings for PE Plastic Pipe and Tubing	D3261
Biaxially Oriented PE (PEO) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter	D3287
“Fiberglass” (Glass-Fiber-Reinforced-Thermosetting Resin) Pressure Pipe	D3517
Fiberglass Sewer and Industries Pressure Pipe	D3754
Reinforced Plastic Mortar Pipe Fittings for Non-Pressure Applications	D3840
Threaded CPVC Plastic Pipe Fittings, Schedule 80	F437
Socket-Type CPVC Plastic Pipe Fittings, Schedule 40	F438
Socket-Type CPVC Plastic Pipe Fittings, Schedule 80	F439
Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter	F714
CPVC Plastic Pipe, Schedules 40 and 80	F441
CPVC Plastic Pipe (SDR-PR)	F442
Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter	F714
Crosslinked Polyethylene (PEX) Tubing	F876
Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems	F877
Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe	F1281
Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure Pipe	F1282
Pressure-Rated Composite Pipe for Elevated Temperature Service	F1335
Cold-Expansion Fittings With Metal Compression-Sleeves for Cross-Linked Polyethylene (PEX) Pipe	F2080
American Water Works Association (AWWA or ANSI/AWWA)	
Reinforced Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids	C300
Prestressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids	C301
Reinforced Concrete Pressure Pipe, Noncylinder Type, for Water and Other Liquids	C302
PVC Pressure Pipe, 4 in. Through 12 in., for Water	C900

Table 926.1 Component Standards and Specifications (Cont'd)

Component	Designation
Miscellaneous Components	
The American Society of Mechanical Engineers (ASME)	
Unified Screw Threads	B1.1
Pipe Threads (Except Dryseal)	B1.20.1
Dryseal Pipe Threads	B1.20.3
Hose Coupling Screw Threads	B1.20.7
Nonmetallic Flat Gaskets for Pipe Flanges	B16.21
Buttwelding Ends for Pipe, Valves, Flanges, and Fittings.	B16.25
Square and Hex Bolts and Screws	B18.2.1
Square and Hex Nuts	B18.2.2
American Society for Testing and Materials (ASTM)	
Structural Steel	A36/A36M
Carbon Steel Track Bolts and Nuts	A183
Alloy-Steel and SS Bolting Materials for HT Service	A193/A193M
Carbon and Alloy Steel Nuts for Bolts for High Pressure and HT Service	A194/A194M
Carbon Steel Bolts and Studs, 60,000 PSI Tensile.	A307
Solder Metal	B32
Threads (60-Deg. Stud) for Glass RTR Pipe.	D1694
Solvent Cement for ABS Plastic Pipe and Fittings	D2235
Solvent Cements for PVC Plastic Pipe and Fittings.	D2564
Solvent Cements for Transition Joints Between ABS and PVC Non-Pressure Piping Components	D3138
Joints for Plastic Pressure Pipes Using Flexible Elastometric Seals	D3139
Solvent Cements for CPVC Plastic Pipe and Fittings.	F493
American Water Works Association (AWWA or ANSI/AWWA)	
Rubber-Gasket Joints for DI and Gray-Iron Pressure Pipe and Fittings	C111/A21.11
American Welding Society (AWS or ANSI/AWS)	
Covered Carbon Steel Arc Welding Electrodes.	A5.1
Iron and Steel Oxyfuel Gas Welding Rods	A5.2
Aluminum and Aluminum Alloy Electrodes for Shielded Metal Arc Welding	A5.3
Covered Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Electrodes	A5.4
Low Alloy Steel Covered Arc Welding Electrodes	A5.5
Covered Copper and Copper Alloy Arc Welding Electrodes.	A5.6
Copper and Copper Alloy Bare Welding Rods and Electrodes.	A5.7
Brazing Filler Metal	A5.8
Corrosion-Resisting Chromium and Chromium-Nickel Steel Bare and Composite Metal	
Cored and Stranded Welding Electrodes and Welding Rods	A5.9
Aluminum and Aluminum Alloy Bare Welding Rods and Electrodes.	A5.10
Tungsten Arc Welding Electrodes (Non-Consumable)	A5.12
Carbon Steel Electrodes and Fluxes for Submerged Arc Welding	A5.17
Carbon Steel Filler Metals for Gas Shielded Arc Welding.	A5.18
Carbon Steel Electrodes for Flux Cored Arc Welding.	A5.20
Flux Cored Corrosion-Resisting Chromium and Chromium-Nickel Steel Electrodes	A5.22
Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding	A5.23
Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)	
Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings	SP-6
Standard Marking System for Valves, Fittings, Flanges, and Unions	SP-25
Pipe Hangers and Supports — Materials, Design, and Manufacture.	SP-58
Society of Automotive Engineers (SAE)	
Hydraulic Tube Fittings.	J514

GENERAL NOTE: The approved years of issue of standards and specifications listed in this Table are given in Mandatory Appendix III.

NOTES:

- (1) Applicability limited to alloy UNS No. C23000.
- (2) See para. 923.1.2 for permissible materials.