ASME B31.9–2004
(Revision of ASME B31.9–1996)

Building Services Piping

ASME Code for Pressure Piping, B31

AN AMERICAN NATIONAL STANDARD



The American Society of Mechanical Engineers

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The next edition of this Code is scheduled for publication in 2008. There will be no addenda issued to ASME B31.9-2004.

ASME issues written replies to inquiries concerning interpretations of technical aspects of the Code. Interpretations are published on the ASME Web site under the Committee Pages at http://www.asme.org/codes/ as they are issued.

Periodically certain actions of the ASME B31 Committee will be published as Cases. While these Cases do not constitute formal revisions of the Code, they may be used in specifications, or otherwise, as representing considered opinions of the Committee. The Cases are not part of the Code and are published separately.

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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 initiated the B31 Project in March 1926 to meet that need. The American Society of Mechanical Engineers 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 Liquid Hydrocarbons and Other Liquids
B31.5, Refrigeration Piping
B31.8, Gas Transmission and Distribution Piping Systems
B31.9, Building Services Piping
B31.11, Slurry Transportation Piping Systems

In 1969, the American Standards Association, renamed the United States of America Standards Institute, became the American National Standards Institute (ANSI), and the B31 Sectional Committee became the B31 Standards Committee. In 1978, The American Society of Mechanical Engineers 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.

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 the American National Standards Institute on August 16, 2004.

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ASME CODE FOR PRESSURE PIPING, B31

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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 assure uniform application of principles and to guide selection and application of piping elements. The Code prohibits designs and practices known to be unsafe and contains warnings where caution, but not prohibition, is warranted.

This Code Section includes:

(a) references to acceptable material specifications and component standards, including dimensional requirements and pressure–temperature ratings

(b) requirements for design of components and assemblies, including pipe supports

(c) requirements and data for evaluation and limitation of stresses, reactions, and movements associated with pressure, temperature changes, and other forces

(d) guidance and limitations on the selection and application of materials, components, and joining methods

(e) requirements for the fabrication, assembly, and erection of piping

(f) requirements for examination, inspection, and testing of piping

It is intended that this Edition of Code Section B31.9 and any subsequent addenda 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 and addenda 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. Addenda may be issued periodically. 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 assure safe piping for the proposed installation.

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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:

(a) 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

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

(c) B31.4, Liquid Transportation Piping — piping for transporting predominantly liquid products between plants and terminals and within terminals, and for pumping, regulating, and metering stations

(d) B31.5, Refrigeration Piping — piping for refrigerants and secondary coolants

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

(f) 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

(g) B31.11, Slurry Transportation Piping — piping for transporting aqueous slurries between plants and terminals, and within terminals and pumping and regulating stations.

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

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

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

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

(d) NFPA 99 Health Care Facilities — medical and laboratory gas systems

(e) NFPA 8503, Standard for Pulverized Fuel Systems. Building and Plumbing Codes.

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 ASME, Secretary, B31 Committee, Three Park Avenue, New York, NY 10016.

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SUMMARY OF CHANGES

Following approval by the B31 Committee and ASME, and after public review, ASME B31.9-2004 was approved by the American National Standards Institute on August 16, 2004.

ASME B31.9-2004 includes editorial changes, revisions, and corrections identified by a margin note, **(04)**, placed next to the affected area.

Page	*Location*	*Change*
1	900.1.2(a)(1)	Revised
3, 5	900.2	Definitions for *chilled water, DN, employer, pipe, piping, piping components,* and *piping system* added
7, 8	900.3	h_g, r, W, W_e, W_f, and Z deleted
9	901.5(b)	Added
13	904.3	(1) Revised in its entirety (2) Figs. 904.3.3A and 904.3.3B and Table 904.3.3 deleted
	904.4.1	Last sentence of first para. revised
17, 18	919.4.1(a)(2)	Former Eq. (9) redesignated as Eq. (8) and revised
27	923.3.4	Added
28	926.4	PEX, PE-AL-PE, and PEX-AL-PEX added
29, 31, 32	Table 926.1	(1) AGA references deleted (2) ASTM F 876 through F 1335 added (3) ASTM F 2014 added
33	Table 926.2	ASTM F 2014 added
34	927.2.1	Revised in its entirety
	927.4.2(c)	Added
36, 37	Fig. 927.4.3B	Revised
	927.5	Revised in its entirety
	927.6	Revised in its entirety
39	930.2	Added
42	936.6.1	Subparagraphs (b) and (c) revised
43	936.6.6(a)	Revised
44	937.5.2	Second sentence revised

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Page	*Location*	*Change*
46	Table I-1	Stress values for ASTM A 53 Class F revised
54, 55	Mandatory Appendix III	Last six ASTM references added

SPECIAL NOTE:

The Interpretations to ASME B31.9 are included in this edition as a separate section for the user's convenience.

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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:

(04) *(1)* water and anti-freeze 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. 900.1.2B.

(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 30 (DN 750) and 0.500 in. (12.7 mm) wall

(2) stainless steel: NPS 12 (DN 300) and 0.500 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 18 (DN 450)

(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

(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)

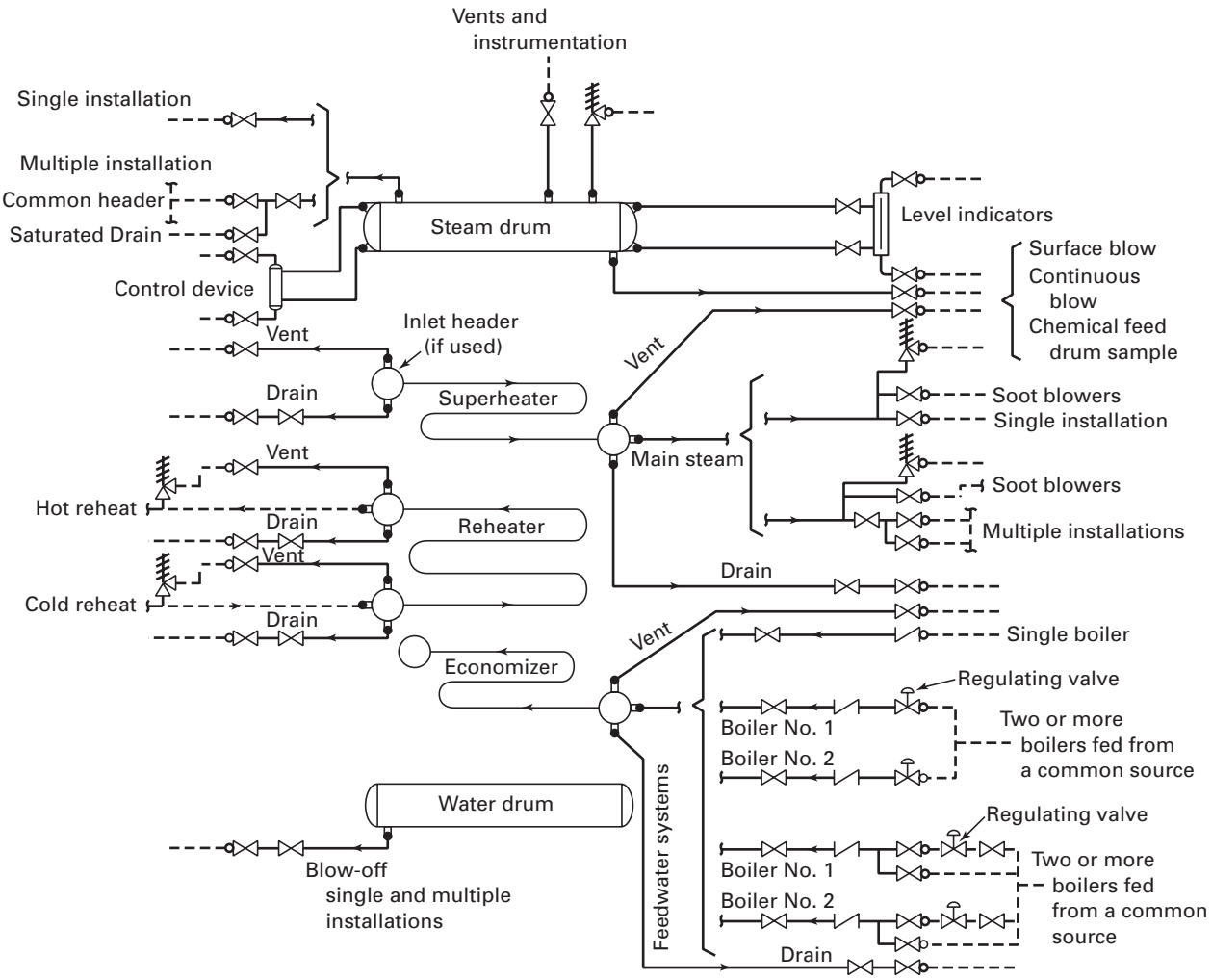
(2) other gases and vapors: 200°F (93°C)

(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,

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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, Introduction, fourth paragraph.

●——— Boiler External Piping and Joint (BEP). See para. 900.1.2(b) for B31.9 Scope.

○- - - - - Nonboiler External Piping and Joint (NBEP).

Fig. 900.1.2B Code Jurisdictional Limits for Piping — Drum Type Boilers

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and equipment covered by the ASME Boiler and Pressure Vessel (BPV) Code.

(04) 900.2 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 shows typical branch connections which do not use fittings.

braze welding: 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 D 93.

brittle failure: a pipe failure mode that exhibits no material deformation visible to the naked eye, i.e., 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 which 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 one inch equal to 25 mm. The pipe is still manufactured in inch sizes.

defect: an imperfection which 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.

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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 CO_2 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.

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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.

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:

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.

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root penetration: the depth that a weld extends into the root of a joint measured on the center line 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

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.

fillet weld: for an equal leg fillet weld, the leg length of the largest isosceles right triangle which can be inscribed within the fillet weld cross section. For an unequal leg fillet weld, the leg lengths of the largest right triangle which can be inscribed within the fillet weld cross section.

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.

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 which 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.

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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.

(04) 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} (m^2)

b = weld size (attachment weld, face of slip-on flange), in. (mm)

C = head or closure factor, dimensionless

d = inside pipe diameter ($D - 2T$), for use in closure and branch connection reinforcement calculations, in.

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)

D = outside pipe diameter, as measured or per dimensional standard, in. (mm)

D_n = diameter equal to nominal pipe size, in. (mm)

e = coefficient of thermal expansion, in./in./°F (mm/m/°C)

E = longitudinal or spiral welded joint efficiency factor, dimensionless (Table 902.4.3)

E_m = modulus of elasticity, psi (kPa) (Table 919.3.1)

f = stress range reduction factor for cyclic conditions, dimensionless

F = casting quality factor, dimensionless

h = thread depth in ASME B1.20.1, in. (mm)

I = moment of inertia, in.^{4} (mm^4)

ksi = kips (1000 lb) per sq in. (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_2 = mean radius of pipe, based on nominal dimensions, in. (mm)

R = anchor or support reaction, lbf (N)

R_1 = effective radius of miter joint; the shortest distance from the pipe center line to the intersection of planes of adjacent miter joints, 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)

S_E = computed expansion stress range, psi (kPa)

S_F = maximum allowable stress in material due to internal pressure considering casting quality factor at design temperature, psi (kPa)

S_h = basic material allowable stress prior to applying joint factor E, at maximum (hot) normal temperature, psi (kPa)

S_L = longitudinal compressive stress, psi (kPa)

S_{LP} = longitudinal stress due to pressure, psi (kPa)

SE = maximum allowable stress in material due to internal pressure, considering joint efficiency factor E at design temperature, psi (kPa)

t_c = minimum required thickness of flat head, closure, or blank, in. (mm)

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t_m = minimum required wall thickness, in. (mm) (see para. 904.1.1)
t_w = weld throat size, in. (mm)
T = measured or minimum specification wall thickness, exclusive of corrosion allowance, in. (mm)
T_n = nominal pipe thickness, in. (mm)
U = distance between anchors, measured in a straight line, ft (m)
v = Poisson's ratio, dimensionless
Y = resultant thermal movement to be absorbed by piping system, 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

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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 startup and shutdown. 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 shutoff 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. (04)

901.7 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

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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 temperature[1]

(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 temperature[1]

(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 temperature[1]

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

(4) two-thirds of yield strength at temperature[1]

(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 D 1598 or analyzed in accordance with ASTM D 2837.

(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 D 1598, or analyzed in accordance with Procedure B of ASTM D 2992. Data obtained by the method of ASTM D 2143 may be used if analyzed by Procedure A of ASTM D 2992.

(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

[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.

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stressed primarily in bending and torsion shall be determined in accordance with ASME B31.1, para. 102.3.2(C), 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 0.25 S_h in Eq. (1) of ASME B31.1, para. 102.3.2(C) 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 A 211 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).

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

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 904.2.1A 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 for unvalved vents to atmosphere. See Fig. 904.2.2 for nomenclature.

Table 904.2.1A Pipe Thickness for Bends

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

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

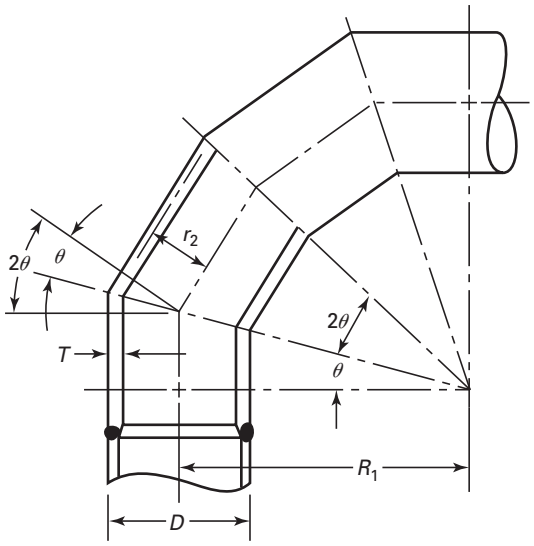


Fig. 904.2.2 Nomenclature for Miter Joints

(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).

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

(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.

(04) 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. 927.4.6A and B 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. 927.4.6B 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, no reinforcement is required. 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.

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

where

D_b = the O.D. of the branch, in. (mm)
D_m = the O.D. of the main, in. (mm)
P = the maximum pressure of the joint without reinforcement, psi (kPa)
SE_b = the allowable stress for the branch material, psi (kPa)
SE_m = the allowable stress of the main 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

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 (04) 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. 927.4.5A. Flat plate closures shall not be secured with a single fillet weld.

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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

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 Appendix II, 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).

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

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 Appendix 6 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.

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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 only be used 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.

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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.

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).

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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.					
		Liquids and Gases [Note (1)]					Saturated Steam and Condensate, All Sizes
		1/4–1	1 1/4–2	2 1/2–4	5–8 [Note (2)]	10–12 [Note (2)]	
50-50 Tin-Lead							
ASTM B 32 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 B 32 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.

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.

(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 (04)

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Table 919.3.1 Moduli of Elasticity and Thermal Expansion Coefficients

Material	Modulus of Elasticity, psi × 10^{-6}	Coefficient of Thermal Expansion, in./in., °F × 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	...
3306	0.13	70.0	...	...	−1.68	0	2.52	...
3406	0.15	60.0	...	...	−1.44	0	2.16	...
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.

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

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 where L/U is more than 2.5. 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 which 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.

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Table 919.3.1 Moduli of Elasticity and Thermal Expansion Coefficients

Linear Thermal Expansion, in./100 ft, Between 70°F and Indicated Temperature, °F										
150	175	200	225	250	275	300	325	350	375	Material
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
...	...	...	...	...	...	...	...	...	...	3306
...	...	...	...	...	...	...	...	...	...	3406
...	...	...	...	...	...	...	...	...	...	PP 1110
...	...	...	...	...	...	...	...	...	...	1208
...	...	...	...	...	...	...	...	...	...	2105
										RTRP

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),

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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-fifth 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 $2\frac{1}{2}$ (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. $\leq$ 1.0), and insulation.

(c) Spacing, Steel Pipe. Figure 921.1.3C 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. 921.1.3D.

(e) Limitations on Charts. The spans in Figs. 921.1.3C and Figs. 921.1.3D 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.

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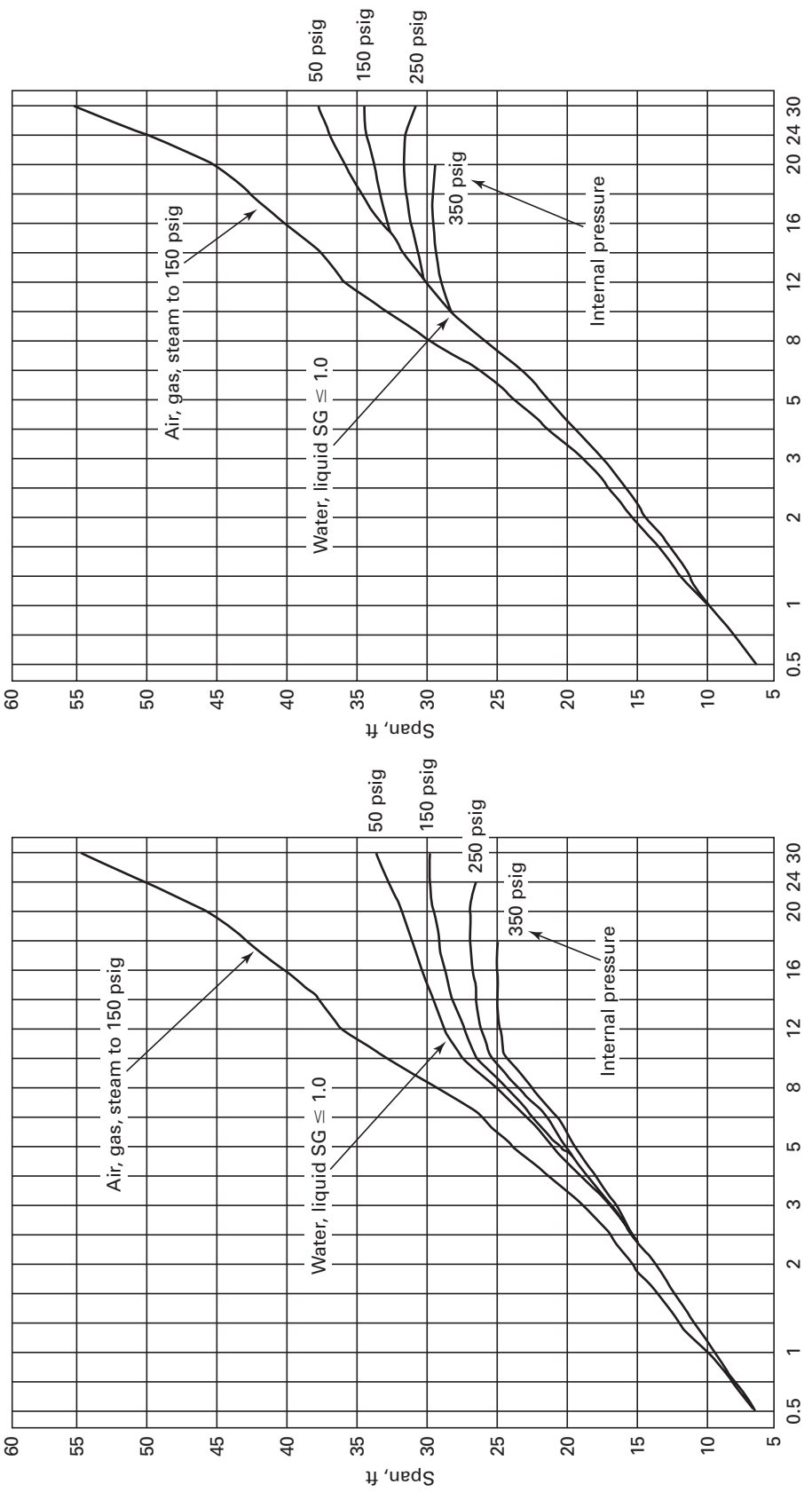
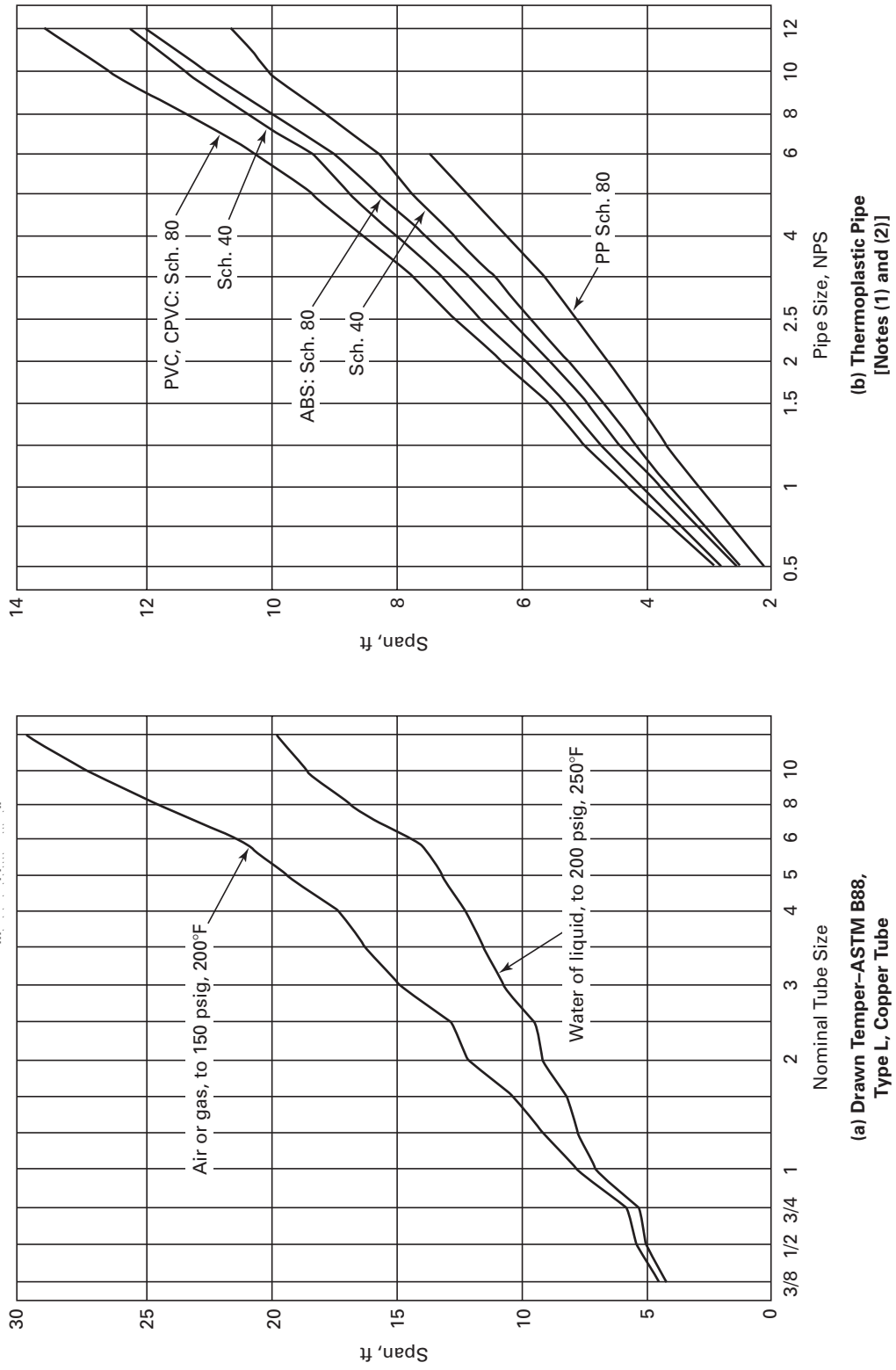


Fig. 921.1.3C Support Spans for Standard Wall Steel Pipe

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.

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NOTES:
(1) Based on pope 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.

Fig. 921.1.3D Support Spans for Copper and Thermoplastic Pipe

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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 $\frac{3}{8}$ in. (9.5 mm) in diameter be used to support pipe NPS $1\frac{1}{2}$ (DN 40) or larger. See Table 921.2.2A 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 A 48 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 A 47 malleable iron may be used for pipe clamps, beam clamps, hanger flanges, clips, bases, swivel rings, and parts of pipe supports.

Table 921.2.2A Capacities of Threaded ASTM A 36 Steel Rods

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

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.

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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 E 488.

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 $4\frac{1}{2}$ 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

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 to open.

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 to open.

(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.

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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, i.e., 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.

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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 I 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 F 412, 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.

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(04) **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.

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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.

(04) **926.4 Abbreviations**

Abbreviations used in Tables 926.1 and 926.2 signify the following:

Abbreviation	Term
	General
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
	Plastics
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
	Composites
PE-AL-PE	polyethylene-aluminum-polyethylene
PEX-AL-PEX	crosslinked polyethylene-aluminum-crosslinked polyethylene

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Table 926.1 Component Standards and Specifications (04)

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
CI Thd 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 Thd 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 $\frac{1}{2}$ 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
Society of Automotive Engineers (SAE)	
Refrigeration Tube Fittings	J513
American Society for Testing and Materials (ASTM)	
Ferritic Malleable Iron Castings	A 47
Gray Iron Castings	A 48
Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless	A 53
Forgings, Carbon Steel, for Piping Components	A 105
Seamless Carbon Steel Pipe for HT Service	A 106
Gray Iron Castings for Valves, Flanges, and Pipe Fittings	A 126
Electric-Resistance-Welded Steel Pipe	A 135
Forgings, Carbon Steel for General Purpose Piping	A 181/A 181M
Cupola Malleable Iron	A 197
Spiral-Welded Steel or Iron Pipe	A 211
Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures	A 234/A 234M
Copper Brazed Steel Tubing	A 254
Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650°F (345°C)	A 278/A 278M
Seamless and Welded Austenitic Stainless Steel Pipes	A 312/A 312M
Ductile Iron Pressure Pipe	A 377
Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures	A 395/A 395M
Wrought Austenitic SS Piping Fittings	A 403/A 403M
Ductile Iron Castings	A 536

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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	A 539
Aluminum-Alloy Sand Castings	B 26/B 26M
Seamless Copper Pipe, Standard Sizes	B 42
Seamless Red Brass Pipe, Standard Sizes	B 43
Steam or Valve Bronze Castings	B 61
Composition Bronze or Ounce Metal Castings	B 62
Seamless Copper Tube, Bright Annealed	B 68/B 68M
Seamless Copper Tube	B 75/B 75M
Seamless Copper Water Tube	B 88/B 88M
Seamless Brass Tube [Note (1)]	B 135/B 135M
Aluminum-Alloy Drawn Seamless Tubes	B 210/B 210M
Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube	B 241/B 241M
Aluminum and Aluminum-Alloy Die, Hand, and Rolled Ring Forgings	B 247/B 247M
General Requirements for Wrought Seamless Copper and Copper-Alloy Tube	B 251/B 251M
Seamless Copper Tube for Air Conditioning and Refrigeration Field Service	B 280
Copper and Copper-Alloy Die Forgings (Hot-Pressed)	B 283
Threadless Copper Pipe	B 302
Factory-Made Wrought Aluminum and Aluminum-Alloy Welding Fittings	B 361
Aluminum-Alloy Formed and Arc Welded Round Tube	B 547
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
SW Reducer Inserts	SP-79
Bronze Gate, Angle, and Check Valves	SP-80
Carbon Steel Pipe Unions — SW and Thd	SP-83
Steel Valves — SW and Thd Ends	SP-84
Cast Iron Globe and Angle Valves, Flanged and Thd Ends	SP-85
Diaphragm Type Valves	SP-88

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Table 926.1 Component Standards and Specifications (Cont'd) (04)

Component	Designation
Nonmetallic Pipe, Composite Pipe, Fittings, Valves, and Flanges	
American Society for Testing and Materials (ASTM)	
Reinforced Concrete Low-Head Pressure Pipe	C 361/C 361M
Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminants for Corrosion Resistant Equipment	C 582
ABS Plastic Pipe, Schedules 40 and 80	D 1527
PVC Plastic Pipe, Schedules 40, 80, and 120	D 1785
PE Plastic Pipe, Schedule 40	D 2104
PE Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter	D 2239
PVC Pipe Pressure Rated Pipe (SDR- Series)	D 2241
ABS Plastic Pipe (SDR-PR)	D 2282
Classification for Machine-Made RTR Pipe	D 2310
PE Plastic Pipe, Schedules 40 and 80 Based on Outside Diameter	D 2447
Threaded PVC Plastic Pipe Fittings, Schedule 80	D 2464
PVC Plastic Pipe Fittings, Schedule 40	D 2466
Socket-Type PVC Plastic Pipe Fittings, Schedule 80	D 2467
ABS Plastic Pipe Fittings, Schedule 40	D 2468
Thermoplastic Gas Pressure Pipe Tubing and Fittings	D 2513
Reinforced Epoxy Resin Piping Gas Pressure Pipe and Fittings	D 2517
Plastic Insert Fittings for PE Plastic Pipe	D 2609
PB Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter	D 2662
PB Plastic Tubing	D 2666
Joints for IPS PVC Using Solvent Cement	D 2672
Socket-Type PE Fittings for Outside Diameter-Controlled PE Pipe and Tubing	B 2683
PE Plastic Tubing	D 2737
CPVC Plastic Hot- and Cold-Water Distribution Systems	D 2846
Filament-Wound RTR Pipe	D 2996
Centrifugally Cast Glass Fiber RTR Pipe	D 2997
PB Plastic Pipe (SDR-PR), Based on Outside Diameter	D 3000
PE Plastic Pipe (SDR-PR), Based on Controlled Outside Diameter	D 3035
Butt Heat Fusion PE Plastic Fittings for PE Plastic Pipe and Tubing	D 3261
Biaxially Oriented PE (PEO) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter	D 3287
PB Plastic Hot- and Cold-Water Distribution Systems	D 3309
Specification for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pressure Pipe	D 3517
Specification for Fiberglass Sewer and Industries Pressure Pipe	D 3754
Specification for Reinforced Plastic Mortar Pipe Fittings for Non-Pressure Applications	D 3840
Threaded CPVC Plastic Pipe Fittings, Schedule 80	F 437
Socket-Type CPVC Plastic Pipe Fittings, Schedule 40	F 438
Socket-Type CPVC Plastic Pipe Fittings, Schedule 80	F 439
CPVC Plastic Pipe, Schedules 40 and 80	F 441
CPVC Plastic Pipe (SDR-PR)	F 442
Standard Specification for Crosslinked Polyethylene (PEX) Tubing	F 876
Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems	F 877
Standard Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe	F 1281
Standard Specification for Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure Pipe	F 1282
Standard Specification for Pressure-Rated Composite Pipe for Elevated Temperature Service	F 1335
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

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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
BW 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	A 36/A 36M
Carbon Steel Track Bolts and Nuts	A 183
Alloy-Steel and SS Bolting Materials for HT Service	A 193/A 193M
Carbon and Alloy Steel Nuts for Bolts for High Pressure and HT Service	A 194/A 194M
Carbon Steel Bolts and Studs, 60,000 PSI Tensile	A 307
Solder Metal	B 32
Threads (60-Deg. Stud) for Glass RTR Pipe	D 1694
Solvent Cement for ABS Plastic Pipe and Fittings	D 2235
Solvent Cements for PVC Plastic Pipe and Fittings	D 2564
Solvent Cements for Transition Joints Between ABS and PVC Non-Pressure Piping Components	D 3138
Joints for Plastic Pressure Pipes Using Flexible Elastometric Seals	D 3139
Solvent Cements for CPVC Plastic Pipe and Fittings	F 493
American Water Works Association (AWWA or ANSI/AWWA)	
Rubber-Gasket Joints for DI and Gray-Iron Pressure Pipe and Fittings	C 111/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.

NOTE:

(1) Applicability limited to alloy UNS No. C23000.

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Table 926.2 Standard Practices (04)

Component	Designation
American Petroleum Institute (API or ANSI/API)	
Fire Test for Soft-Seated Quarter-Turn Valves, Fourth Edition	Std 607-1993
American Society for Testing and Materials (ASTM)	
Test Methods for Flash Point by Pensky-Martens Closed Tester	D 93
Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure	D 1598
Test Method for Cyclic Pressure Strength of RTP Pipe	D 2143
Practice for Heat Joining of Polyolefin Pipe and Fittings	D 2657
Practice for Underground Installation of Thermoplastic Pressure Piping	D 2774
Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials	D 2837
Practice for Making Solvent-Cemented Joints With PVC Pipe and Fittings	D 2855
Method for Obtaining Hydrostatic Design Basis for RTR Pipe and Fittings	D 2992
Practice for Flaring Polyolefin Pipe and Tubing	D 3140
Test Method for Strength of Anchors in Concrete and Masonary Elements	E 488
Practice for Safe Handling of Solvent Cements Used for Joining Thermoplastic Pipe and Fittings	F 402
Definition of Terms Relating to Plastic Piping Systems	F 412
Standard Specification for Non-Reinforced Extruded Tee Connections for Piping Applications	F 2014
American Water Works Association (AWWA or ANSI/AWWA)	
Thickness Design of DI Pipe	C150/A21.50
Installation of DI Water Mains and Other Appurtenances	C600
Copper Development Association (CDA)	
Copper Tube Handbook	...
Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)	
Pipe Hangers and Supports — Selection and Application	SP-69
Pipe Hangers and Supports — Fabrication and Installation Practices	SP-89
Guidelines on Terminology for Pipe Hangers and Supports	SP-90

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

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Chapter V
Fabrication, Assembly, and Erection

927 WELDED FABRICATION OF METALS

927.1 General

Welding shall be performed in accordance with the qualification requirements of para. 927.5. Limitations on imperfections and acceptance standards are as stated in Chapter VI or in the engineering design.

927.2 Materials

(04) **927.2.1 Electrodes and Filler Metal.** Welding electrodes and filler metal, including consumable inserts, shall conform to the requirements of the ASME BPV Code, Section II, Part C. An electrode or filler metal not conforming to the above may be used provided the WPS, welders, and welding operators who will follow the WPS have been qualified as required by ASME BPV Code, Section IX.

Unless otherwise specified by the designer, welding electrodes and filler metals used shall produce weld metal that complies with the following:

(a) The nominal tensile strength of the weld metal shall equal or exceed the tensile strength of the base metals being joined.

(b) If base metals of different tensile strengths are to be joined, the nominal tensile strength of the weld metal shall equal or exceed the tensile strength of the weaker of the two.

(c) The nominal chemical analysis of the weld metal shall be the same as the nominal chemical analysis of the major alloying elements of the base metal.

(d) If base metals of differing chemical analysis are being joined, the nominal chemical analysis of the weld metal shall be the same as either base metal or an intermediate composition, except as specified below for austenitic steels joined to ferritic steels.

(e) When austenitic steels are joined to ferritic steels, the weld metal shall have an austenitic structure.

(f) For nonferrous metals, the weld metal shall be that recommended by the manufacturer of the nonferrous metal or by industry associations for that metal.

(g) For unusual materials or combinations of materials, the design engineer shall specify the weld metal that is required.

927.2.2 Backing Rings. Backing rings are not required but when used shall be of a material compatible with the base metal and shall fit the inside diameter of the pipe. Backing rings may be tacked to the inside of the pipe and shall be fused into the root of the weld.

927.3 Preparation

927.3.1 Butt and Miter Welds

(a) End Preparation. End preparation for butt and miter joint welds shall be as shown in the welding procedure specification. The basic bevel angles shown in ASME B16.25 may be used. Oxygen or arc cutting is acceptable only if the cut is reasonably smooth and true. Discoloration that may remain on the flame-cut surface is not considered to be detrimental oxidation.

(b) Cleaning. Weld areas and surfaces shall be clean and free from paint, oil, rust, scale, or any other material detrimental to the weld or base metal before welding begins and shall be kept clean during welding. All slag shall be cleaned from flame-cut surfaces.

(c) Internal Alignment. The prepared ends of piping components to be joined shall be aligned as accurately as is practicable within commercial tolerances on diameter, wall thickness, and out-of-roundness. Alignment shall be preserved during welding.

(d) Spacing. The root opening of the joint shall be as given in the welding procedure.

927.3.2 Fillet Welds. If fillet welding is used in joining piping components, applicable requirements of para. 927.3.1 shall be met in preparing the parts for welding.

927.4 Rules for Welding

927.4.1 General

(a) Protection of Work. No welding shall be done if there is impingement of rain, snow, sleet, or high wind on the weld area, or if the weld area is frosted or wet.

(b) Preheat. Preheating shall be as required by the Welding Procedure Specification.

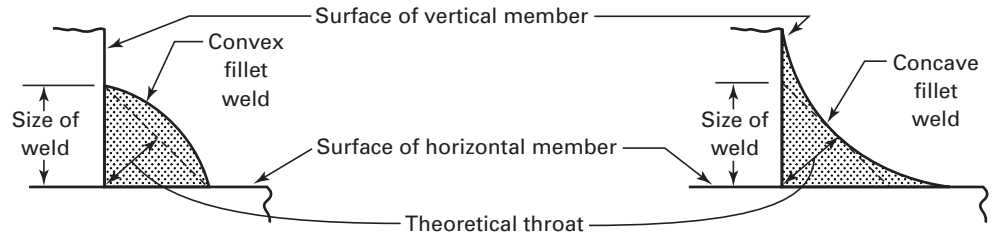
927.4.2 Butt and Miter Welds

(a) Tack Welds. Tack welds shall be made by a qualified welder or shall be removed. Tack welds that have cracked shall be removed. Tack welds shall be made with filler metal that is compatible with the first pass filler metal and shall be fused with the first pass.

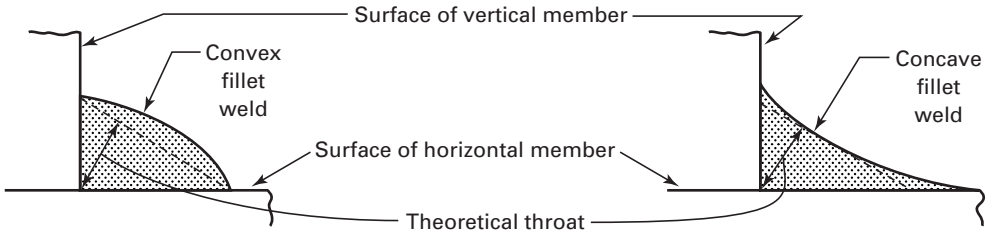
(b) External Alignment. If the external surfaces of the two components are not aligned, the weld shall be tapered between the surfaces.

(c) Joint Design and Fit-up. Pipe shall be cut, beveled, and tack welded, or otherwise held in alignment to provide a good fit that will permit full-penetration welding. (04)

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(a) Equal Leg Fillet Weld [Note (1)]



(b) Unequal Leg Fillet Weld [Note (2)]

NOTES:
(1) The size of an equal leg fillet weld is the length of the largest inscribed isosceles right triangle. (Theoretical throat = 0.707 × size.)
(2) The size of an unequal leg fillet weld is the leg length of the largest right triangle that can be inscribed within the weld cross section [e.g., $\frac{1}{2}$ in. × $\frac{3}{4}$ in. (12.7 mm × 19 mm)].

Fig. 927.4.3A Fillet Weld Size

927.4.3 Fillet and Socket Welds

(a) Welding. The applicable provisions of para. 927.4.2(a) shall be followed.

(b) Contour. Fillet and socket welds may vary from convex to concave. The size of a fillet weld is determined as shown in Fig. 927.4.3A.

(c) Details. Minimum fillet welds for slip-on flanges and socket welding components are shown in Figs. 927.4.3B and C.

927.4.4 Seal Welds. If seal welding of threaded joints is performed, the surfaces shall be cleaned and all exposed threads shall be covered by the seal weld. Seal welding shall be done by qualified welders.

927.4.5 Welded Flat Heads. Typical minimum weld sizes for attachment of flat heads are shown in Fig. 927.4.5A. Attachment methods shown in Fig. 927.4.5B are not acceptable.

927.4.6 Welded Branches

(a) Branch Connections. Figure 927.4.6A illustrates welded branch connections with and without added reinforcing. No attempt has been made to show all acceptable types of constructions. The fact that one type of construction is illustrated does not indicate that it is recommended over other types not shown.

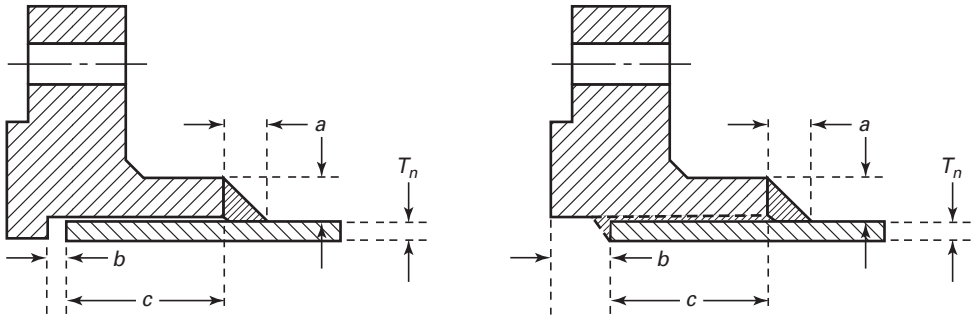
(b) Weld Details. Figure 927.4.6B shows basic types of welds used in fabricating branch connections. The locations and minimum sizes of welds shall conform to the requirements of this figure.

(c) Branch Contours. Branch connections (including integrally reinforced welding outlet fittings) that abut the outside surface of the main pipe wall, or are inserted into an opening in the main pipe wall shall have opening and branch contours that provide a good fit and that will permit a fully penetrated groove weld.

(d) Reinforcement. In branch connections having reinforcement pads or saddles, the reinforcement shall be attached by welds around the branch pipe and the outer periphery, as shown in Fig. 927.4.6A, sketch (b). A vent hole shall be provided (at the side, not at the crotch) in the ring or saddle to reveal leakage in the weld between branch and main and to provide venting during welding or heat treatment. Rings or saddles may be made in more than one piece if the joints between the pieces have adequate strength and if each piece is provided with a vent hole. A good fit shall be provided between rings or saddles and the parts to which they are attached.

927.4.7 Structural Attachments and Supports. Welds for structural attachments and supports shall be fully penetrated groove welds or fillet welds, unless otherwise

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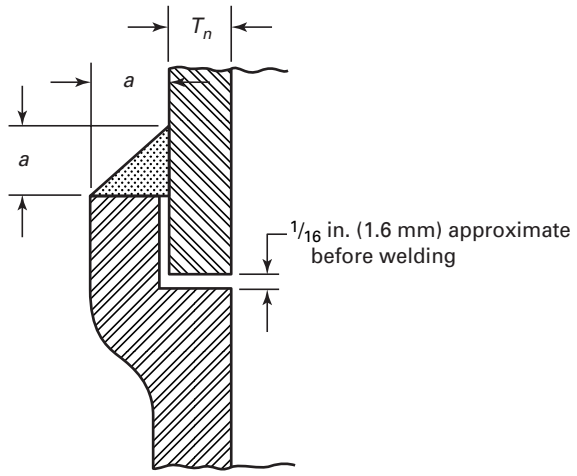


a = weld size: the lesser of $1.4T_n$ or the thickness of the hub, but not less than $\frac{1}{8}$ in. (3 mm)
b = setback distance: $\frac{1}{16}$ in. (1.5 mm) minimum if a flange face seal weld is not used. If a flange face seal weld is used, the minimum shall be that necessary to avoid damage to the gasket surface due to welding.
c = depth of insertion: minimum of the greater of T_n or $\frac{1}{4}$ in. (6 mm)
T_n = nominal wall thickness

GENERAL NOTES:
(a) These sketches illustrate some acceptable methods for attachment of slip-on and socket welding flanges.
(b) Welding of the flange face seal weld is optional unless specified in the engineering design.
(c) Depth of insertion shown is for illustration only.

(04)

Fig. 927.4.3B Minimum Weld Size, Setback, and Depth of Insertion for Slip-On and Socket Weld Flanges



a = the greater of 1.1 T_n or $\frac{1}{8}$ in. (3.2 mm)

Fig. 927.4.3C Minimum Welding Dimensions for Socket-Welding Components Other Than Flanges

specified in the engineering design. Attachment welds shall be made by qualified welders.

927.4.8 Weld Defect Repairs. Defects in welds shall be removed to sound metal. Repair welds are to be made in accordance with the procedure used for the original welds, or by another welding method only if it is to a qualified procedure, recognizing that the cavity to be repaired may differ in contour and dimensions from the original joint.

927.5 Qualification (04)

The employer is responsible for

(a) the welding performed by personnel of his organization

(b) conducting the qualification tests required to qualify the welding procedure specification (WPS) used by personnel in his organization, except as provided in paras. 927.6.1 and 927.6.2

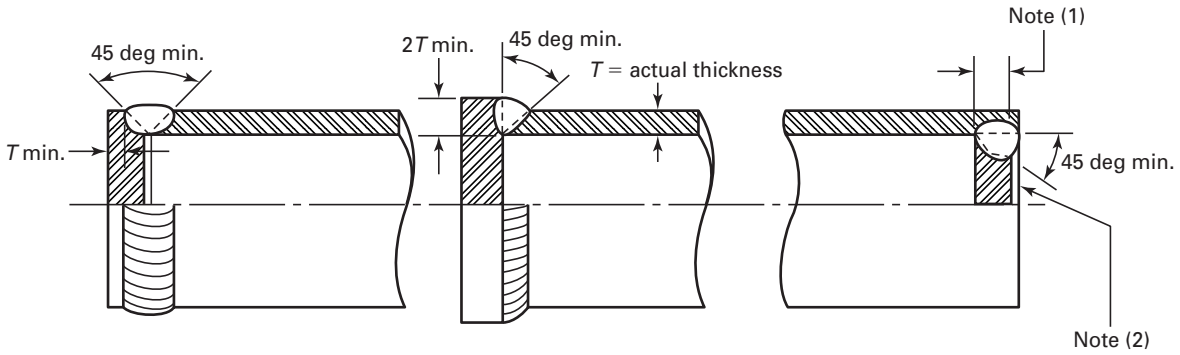
(c) conducting the qualification tests required to qualify the welders and welding operators, except as provided in para. 927.6.3

927.6 Qualification Requirements (04)

Welding Procedure Specifications (WPSs) to be followed in production welding shall be prepared and qualified; welders and welding operators shall be qualified as required by ASME BPV Code, Section IX, except as modified by the following:

927.6.1 Standard Welding Procedures. Standard Welding Procedure Specifications (SWPSs) published by the American Welding Society and listed in Appendix E of ASME BPV Code, Section IX are permitted for code construction within the limitations established by Article V of ASME BPV Code, Section IX, including performing either the demonstration weld described in

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NOTES:
(1) Greater of: 2 × required pipe thickness, or 1.25 × actual pipe thickness, but need not exceed required minimum thickness of closure.
(2) Pipe may project beyond weld. Closure may be beveled (45 deg max.) beyond weld.

Fig. 927.4.5A Acceptable Welds for Flat Heads

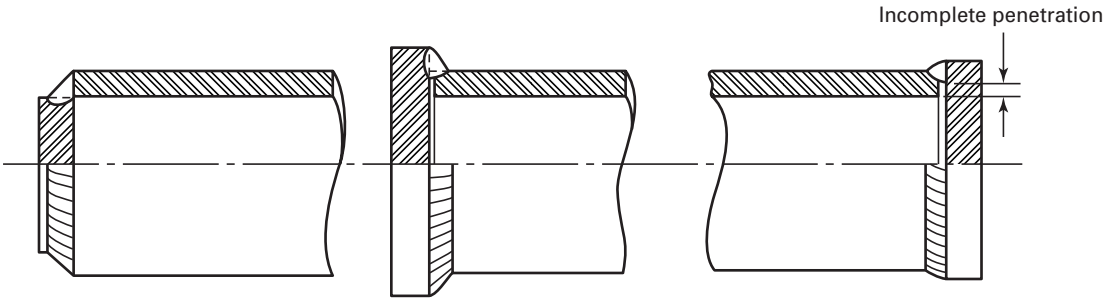


Fig. 927.4.5B Unacceptable Welds for Flat Heads

Section IX, QW-500 or by qualifying one welder following each SWPS.

927.6.2 Procedure Qualification by Others. In order to avoid duplication of effort and subject to the approval of the owner, WPSs qualified by a technically competent group or agency may be used, provided the following are met:

(a) The WPSs meet the requirements of ASME BPV Code, Section IX and any additional qualification requirements of this Code.

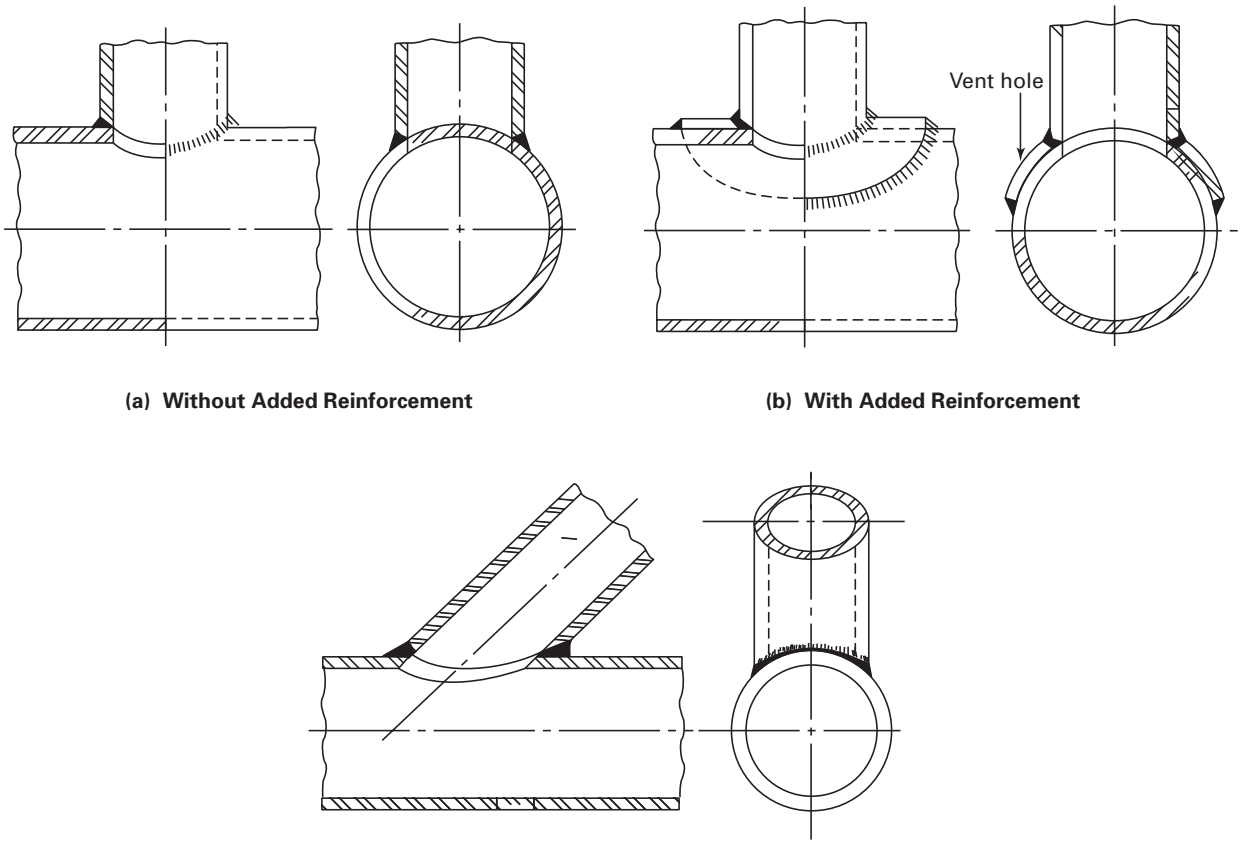
(b) The employer has qualified at least one welder or welding operator following each WPS.

(c) The employer's business name shall be shown on each WPS and on each qualification record. In addition, qualification records shall be signed and dated by the employer, thereby accepting responsibility for the qualifications performed by others.

927.6.3 Performance Qualification by Others. In order to avoid duplication of effort and subject to the approval of the owner, an employer may accept the performance qualification of a welder or welding operator made by a previous employer. This acceptance is limited to performance qualifications that were made on pipe or tube test coupons. The new employer shall have the WPS that was followed during qualification or an equivalent WPS that is within the limits of the essential variables set forth in ASME BPV Code, Section IX. An employer accepting such qualification tests shall obtain a copy of the performance qualification test record from the previous employer. The record shall show the name of the employer by whom the welder or welding operator was qualified and the date of that qualification. A record showing use of the process(es) from the date of the welder's qualification as required by ASME BPV Code, Section IX, QW-322 shall be available. The new employer's business name shall be shown on the qualification record, and it shall be signed and dated by the employer, thereby accepting responsibility for the qualifications performed by others.

927.6.4 Qualification Records. The employer shall maintain copies of the procedure and performance qualification records specified by ASME BPV Code, Section

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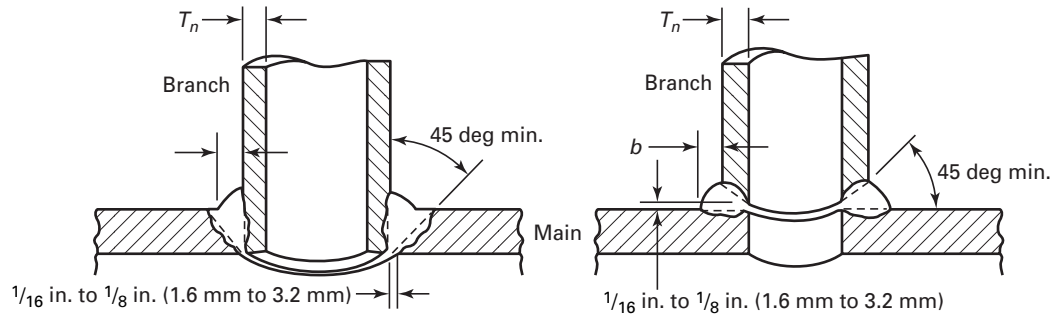


(a) Without Added Reinforcement

(b) With Added Reinforcement

(c) Angular Branch Without Added Reinforcement

Fig. 927.4.6A Typical Weld Branch Connections



(a) Inserted Branch

(b) Set-on Branch

b = the lesser of T_n (branch) or 1/4 in. (6.4 mm)

Fig. 927.4.6B Typical Weld Details

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IX that shall be available to the owner or the owner's agent and the Inspector at the location where welding is being done.

928 BRAZING AND SOLDERING OF METALS

928.1 Brazing

928.1.1 Brazing Materials

(a) Filler Metal. The brazing filler metal shall conform to an applicable AWS classification.

(b) Flux. When required, fluxes shall be compatible with the materials brazed and with the filler metal used. Flux residue should be removed when joints are completed.

928.1.2 Preparation and Technique. The technique for brazing in the Copper Tube Handbook of the Copper Development Association shall be followed.

928.1.3 Brazing Qualification. Brazing procedure and performance qualification are not required. If qualification is specified in the engineering design, the requirements in the ASME BPV Code, Section IX are acceptable.

928.2 Soldering

928.2.1 Materials

(a) Filler Metal. Filler metal shall conform to the applicable ASTM specification. Solder shall melt and flow freely within the specified temperature range.

(b) Flux. Flux should be used to prevent oxidation during soldering and to promote surface wettability.

928.2.2 Preparation and Technique. The technique for soldering in the Copper Tube Handbook of the Copper Development Association shall be followed.

929 BENDING

929.1 General

Pipe may be bent to any radius by any hot or cold method that results in a bend surface free of cracks and substantially free of buckles. Such bends shall meet the design requirements of para. 904.2.1. This shall not prohibit the use of creased or corrugated bends if specified in the engineering design.

930 FORMING

930.1 General

Piping components may be formed (by swaging, lapping, or upsetting of pipe ends, by extrusion of necks, etc.) by any suitable hot or cold method that results in formed surfaces that conform to specified dimensions and are uniform and free of cracks and tears.

930.2 Mechanically Formed Extruded Outlets in Copper Tube (04)

(a) Mechanically formed extruded outlets shall be perpendicular to the axis of the run tube (header). They shall be formed by drilling a pilot hole and drawing out the tube surface to form a collar having a height of not less than three times the thickness of the branch wall. The collaring device shall be such as to assure proper assembly of the joint.

(b) The inner branch tube end shall conform to the shape of the inner curve of the run tube. Insertion of the branch tube shall be controlled to assure alignment with specified depth into the collar without extending into the flow stream so as to provide internal reinforcement to the collar.

(c) Branches can be formed up to the run tube size as shown in ASTM F 2014. Forming procedures shall be in accordance with the tool manufacturer's recommendations.

(d) All joints shall be brazed in accordance with para. 928.1.

(e) The allowable pressure for the joint shall be the lowest value calculated by Eqs. (10), (11), or (12).

$$P = \frac{S\left[D_b T_m + 5.00\ (T_b + T_m)\right]}{D_b\ (D_m + 2.5)} \tag{10}$$

$$P = \frac{2ST_m}{D_m} \tag{11}$$

$$P = \frac{2S_b T_b}{D_b} \tag{12}$$

where

D_b = branch tube outside diameter, in. (mm)
D_m = main tube outside diameter, in. (mm)
S = allowable stress of the material, psi (kPa)
T_b = branch tube wall thickness, net of mill tolerance and corrosion, in. (mm)
T_m = main tube wall thickness, net of mill tolerance and corrosion, in. (mm)

931 HEAT TREATMENT

The materials and material thicknesses permitted under this Code do not require heat treatment. If the engineering design specifies heat treatment after welding, these requirements shall be made part of the Welding Procedure Specification.

934 FABRICATION OF NONMETALS

934.1 Joining Thermoplastic Piping

934.1.1 Materials. Adhesives, cements, and sealers used to join piping components shall be compatible with the materials being joined and shall conform to applicable ASTM specifications. Joining materials that have

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deteriorated by exposure to air, that are beyond the shelf life recommended by the manufacturer, or that will not spread smoothly shall not be used.

934.1.2 Solvent Cemented Joints

(a) Preparation. PVC and CPVC surfaces to be solvent cemented shall be cleaned. Cleaning for ABS shall conform to ASTM D 2235. Cuts shall be free of burrs. Circumferential cuts shall be as square as those obtained by use of a saw with miter box. A slight interference fit between pipe and fitting socket is preferred, and diametral clearance between pipe and entrance of socket shall not exceed 0.04 in. (1.0 mm). This fit shall be checked before solvent cementing.

(b) Procedure. Solvent cemented joints shall be made in accordance with ASTM D 2855. Solvent cements for thermoplastics shall conform to the following specifications:

Material	ASTM Specification
PVC	D 2564
CPVC	D 2846
ABS	D 2235

Application of cement to both surfaces and assembly of the surfaces shall produce a continuous bond and a small fillet of cement at the outside of the joint. For branch connections not using a tee, a full reinforcement saddle with integral branch socket shall be cemented to the main pipe over its entire contact surface. In addition, the saddle shall be further secured to the main pipe by wrapping glass fiber tape saturated with epoxy resin around the saddle and the circumference of the pipe. Solvent cement shall be handled as recommended in ASTM F 402.

934.1.3 Heat Fusion Joints

(a) Preparation. Surfaces to be heat fused together shall be cleaned free of foreign material and surface film. Cuts shall be free from burrs, and circumferential cuts shall be as square as those obtained by use of a saw with miter box. Fixtures shall be used to align pipe and fitting when the joint is made.

(b) Technique. Heat fusion joints for polyethylene, polypropylene, and other thermoplastics commonly joined by heat fusion shall be made in accordance with procedures in ASTM D 2657, Techniques I — Socket Fusion or II — Butt Fusion, and as recommended by the manufacturer. Uniform heating of both surfaces and their assembly shall produce a continuous homogeneous bond between them and a small fillet of fused material at the outside of the joint. Branches shall be made only by use of molded fittings.

934.1.4 Flared Joints and Elastomeric Sealed Joints

(a) Flared Joints. Flared joints shall be made in accordance with ASTM D 3140.

(b) Elastomeric Sealed Joints. Elastomeric sealed joints shall be made in accordance with ASTM D 3139.

934.2 Reinforced Thermosetting Resin Piping Joints

934.2.1 Materials. The provisions of para. 934.1.1 shall also apply to reinforced thermosetting resin pipe.

934.2.2 Preparation. Cutting of pipe shall be done without chipping or cracking it, particularly the inner surface of centrifugally cast pipe. Pipe shall be preheated if necessary to comply with the above requirement. Cuts shall be free from burrs, and circumferential cuts shall be as square as those obtained by use of a saw with miter box. For branch connections, holes in the main pipe shall be made with a hole saw. Mold release agent and other material that would interfere with adhesion shall be sanded or otherwise removed from surfaces to be cemented.

934.2.3 Chemical Setting Adhesive Joints. Chemical setting adhesive joints shall be made in accordance with the manufacturer's recommendations. Application of adhesive to the surfaces and their assembly shall produce a continuous bond between them.

For branch connections, a full reinforcement saddle having an integral short length of branch pipe shall be used. The branch shall project enough to complete a nozzle or to join to the branch pipe. The cut edges of the hole in the main pipe shall be sealed with cement at the time the saddle is cemented to the main pipe.

934.2.4 Hand Lay-Up Joints. Application of plies of reinforcement saturated with catalyzed resin to the surfaces to be joined shall produce a continuous structure with them. Cuts shall be sealed to protect the reinforcement from the contents of the pipe. Thickness of the laid-up portion shall be at least equal to the pipe thickness.

934.3 Repair of Defective Work

Defective material, joints, and other workmanship in nonmetallic piping that fails to meet the requirements of para. 936 and of the engineering design shall be repaired by an acceptable method or shall be replaced. Repair of defects in plastic piping by use of a patching saddle is an acceptable method.

935 ASSEMBLY

935.1 General

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

935.2 Bolting Procedure

935.2.1 Alignment. Flanged joints shall be fitted up so that the gasket contact faces, prior to bolting, bear uniformly on the gasket, and then shall be made up with relatively uniform bolt stress.

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935.2.2 Gasket Loading. In bolting gasketed flanged joints, the gasket shall be uniformly compressed in accordance with the design principles applicable to the type of gasket used.

935.2.3 Steel-to-Iron Flanged Joints. When bolting raised-face steel flanges to flat-face cast iron flanges, care shall be used to prevent damage to the cast iron flanges.

935.2.4 Bolt Engagement. All bolts and nuts shall be fully engaged.

935.3 Bell and Spigot Joints

935.3.1 Caulked Joints. Caulked bell and spigot joints shall be assembled using oakum and poured lead or other joint compounds suitable for the service. Assembly of cast iron bell and spigot pressure piping shall meet the requirements of ANSI/AWWA C600.

935.3.2 Elastomeric Joints. Bell and spigot joints using elastomeric gaskets shall be assembled in accordance with the manufacturer's recommendations.

935.4 Threaded Piping

935.4.1 Threading. Dimensions of threaded joints shall conform to the applicable standard listed in Table 926.1. Threads shall be clean and free of breaks and tears.

935.4.2 Joint Compound. Any compound or lubricant used in threaded joints shall be suitable for the service conditions, and shall not react unfavorably with either the service fluid or the piping materials.

935.4.3 Seal Welded Joints. Threaded joints that are to be seal welded shall be assembled without thread compound.

935.4.4 Backing Off. Backing off of threaded joints to facilitate alignment of the pipe is not permitted.

935.4.5 Threaded Plastic Pipe. Strap wrenches or other full circumference wrenches shall be used to tighten threaded joints. Tools and other devices used to hold or apply forces shall not leave the surface scored or deeply scratched. For RTR piping, threads shall be coated with sufficient catalyzed resin to cover the threads and completely fill the clearance between pipe and fitting.

935.5 Flare Joints

Ends of tubing shall be cut square and deburred. No scratches, breaks, cracks, or other mars at the sealing surface of the flare shall be permitted.

935.6 Ferrule Bite Joints

Ends of tubing shall be cut square and deburred. No scratches, breaks, or other mars on the outside surface of the tubing at the fitting shall be permitted. In tightening the nut, only sufficient torque shall be used to "bite" lightly and uniformly into the tube.

935.7 Compression Joints

Ends of tubing shall be cut square and deburred. No scratches, breaks, or mars are permitted on the outside of the tube at the fitting.

935.8 Other Mechanical and Proprietary Joints

Grooved, expanded, rolled, O-ring, clamp, gland, and other joints permitted by para. 913 shall be assembled in accordance with the manufacturer's instructions.

935.9 Borosilicate Glass Piping

Glass-to-glass connections shall be made with clamp compression type couplings. Closure pieces should preferably be furnished to exact dimension. If necessary, pipe may be field cut and beaded according to manufacturer's instructions. Beaded-to-plain end connections may be made with couplings specially designed for this purpose. Alignment and support for all glass piping shall be verified and adjusted in accordance with manufacturer's instructions before joints are tightened.

935.10 Equipment Connections

When connections are made to equipment or strain-sensitive piping components, care should be taken to avoid misalignment which can introduce undesirable end reactions.

935.11 Cold Spring

Before assembling joints to be cold sprung, supports, guides, and anchors shall be examined to verify that they will not interfere with desired movement or cause undesired movements. The gap or overlap prior to final assembly shall be checked and corrected if necessary to conform to that shown on the drawing.

935.12 Valve Installation

Installation of valves with the stem below the horizontal is not recommended.

935.13 Repair of Defective Work

Joints that leak during test shall be tightened within limits of procedures or manufacturer's instructions. Do not attempt to tighten leaking joints with pneumatic test pressure on the system. Joints that cannot be safely tightened shall be replaced. Assemblies rejected during examination shall be repaired and reassembled or replaced. Replace any glass piping component that is chipped or scratched.

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Chapter VI
Inspection, Examination, and Testing

936 INSPECTION AND EXAMINATION

936.1 General

Inspection applies to quality assurance functions performed by the owner, or for the owner by persons other than the manufacturer, fabricator, or erector. Examination applies to quality control functions performed by personnel employed by the manufacturer, fabricator, or erector of the piping.

936.1.1 Quality System Program. A quality system program is not required by this Code. If a system is required by the engineering design, the program in Nonmandatory Appendix A or a similar program acceptable to the owner may be used.

936.2 Required Inspection

Prior to initial operation, it is the owner's responsibility to verify that all required examination and testing have been completed and to inspect the piping, or have it inspected, to the extent necessary to satisfy himself that it conforms to all applicable requirements of this Code and the engineering design.

936.2.1 Access to the Work. The owner and his representatives shall have access to any place where work concerned with the piping is being performed. This includes manufacture, fabrication, assembly, erection, examination, and testing of the piping.

936.2.2 Rights of Owner. The owner and his representatives shall have the right to audit any examinations, to inspect the piping using examination methods specified in the engineering design, and to review all certifications and records.

936.3 Responsibility for Examination

Inspection does not relieve the manufacturer, fabricator, or erector of responsibility for performing all required examinations and preparing suitable records for the owner's use.

936.4 Methods of Examination

The methods described herein shall be performed by competent personnel.

936.4.1 Visual Examination. Visual examination is observation of the portions of materials, components, joints, supports, and other piping elements that are or can be exposed to view before, during, or after manufacture, fabrication, assembly, or erection. This examination includes verification of Code and engineering design requirements for materials and components, dimensions, joint preparation, alignment, joining practices, supports, assembly, and erection.

936.5 Type and Extent of Required Examination

Unless otherwise specified in the engineering design, the type of examination shall be visual examination in accordance with the method in para. 936.4.1.

If the degree of examination and inspection or the basis for rejection is to be more rigorous than required by this Code, it shall be a matter of prior agreement between the fabricator or installer and the purchaser.

936.6 Acceptance Criteria

Imperfections or indications revealed by examination shall be evaluated in accordance with the following criteria. They are acceptable unless they exceed the specified limitations. Those that exceed the stated limits are defects, and the work shall be repaired or replaced in accordance with the appropriate requirements in Chapter V. Acceptance criteria in para. 936.6 not detectable by visual examination are included to indicate a minimum quality level acceptable under this Code.

936.6.1 Girth Welds and Groove Welds. Limitations on imperfections are as follows. (04)

(a) Cracks. None permitted.

(b) Lack of Fusion. The length of unfused areas shall not be more than 20% of the circumference of the pipe, or of the total length of the weld, and not more than 25% in any 6 in. (152 mm) of weld.

(c) Incomplete Penetration. The total joint penetration shall not be less than the thickness of the thinner of the components being joined, except that incomplete root penetration is acceptable if it does not exceed the lesser of $\frac{1}{32}$ in. (1 mm) or 20% of the required thickness, and its extent is not more than 25% in any 6 in. (152 mm) of weld.

(d) Undercut and Reinforcement. Undercut shall not exceed the lesser of $\frac{1}{32}$ in. (1 mm) or $12\frac{1}{2}$% of wall thickness. Thickness of weld reinforcement shall not exceed $\frac{3}{16}$ in. (4.8 mm).

(e) Concave Root. Concavity of the root surface shall not reduce the total thickness of the joint, including reinforcement, to less than the thickness of the thinner of the components being joined.

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(f) Excess Root Penetration. The excess shall not exceed the lesser of $\frac{1}{8}$ in. (3.2 mm) or 5% of the inside diameter of the pipe.

(g) Weld Surfaces. There shall be no overlaps or abrupt ridges and valleys.

936.6.2 Fillet Welds. Limitations on imperfections in fillet, socket, and seal welds are the same as in para. 936.6.1 for cracks, lack of fusion, undercut, and weld surfaces.

936.6.3 Brazed and Soldered Joints. Limitations on imperfections in brazed and soldered joints are as follows.

(a) Penetration of filler metal inside the pipe shall not exceed 100% of the wall thickness.

(b) There shall be no visible unfilled joint space.

(c) There shall be no visible evidence of excessive overheating.

936.6.4 Threaded Joints. Limitations on imperfections for ASME B1.20.1 threaded pipe joints are as follows.

(a) No more than six and no less than two threads shall be visible after makeup of the joint.

(b) There shall be no severe chipping or tearing of visible threads.

936.6.5 Caulked and Leaded Joints. Limitations on imperfections in caulked and leaded joints are as follows:

(a) The finished joint shall be within $\frac{1}{4}$ in. (6.4 mm) of the rim of the bell.

(b) In the finished joint, the spigot shall be centered in the bell within $\frac{1}{8}$ in. (3.2 mm).

(c) The joint shall be made in a continuous pour.

936.6.6 Flanged Joints. Limitations on imperfections in flanged joints are as follows:

(04) *(a)* When observed during assembly, the flange faces shall be parallel within 1 deg, and the force required to align pipe axes shall not exceed 10 ft·lb (14 N·m) per in. (25 mm) of nominal pipe diameter.

(b) Bolts and nuts shall be fully engaged.

936.6.7 Flared, Flareless, and Compression Joints. Limitations on imperfections in flared, flareless, and compression joints are as follows:

(a) There shall be no cracks in flare or tube end.

(b) Tube ends shall be cut square (visual).

(c) Tube ends shall be free of distortion or grooves that would hinder assembly or sealing.

(d) Negligible force shall be required to align ends.

936.6.8 Mechanical and Proprietary Joints. Imperfections in mechanical and proprietary joints shall be within the limitations established by the manufacturer.

936.6.9 Solvent-Cemented, Adhesive, and Heat-Fusion Joints. Limitations on imperfections in solvent-cemented, adhesive and heat-fusion joints are as follows:

(a) Internal protrusion shall not exceed 50% of wall thickness for solvent-cemented and 25% for adhesive and heat-fusion joints.

(b) There shall be no visible unfilled or unbonded areas.

936.6.10 Hand Lay-Up Joints. Limitations on imperfections in hand lay-up joints are as follows:

(a) There shall be no visible evidence of lack of bonding.

(b) The length of the laid-up joint shall be at least the lesser of 4 in. (102 mm) or the nominal diameter of the pipe.

(c) The thickness of the laid-up joint shall be at least equal to the wall thickness of the thinner pipe.

937 LEAK TESTING

937.1 General

Prior to initial operation, each piping system shall be tested for leakage. Hydrostatic testing in accordance with para. 937.3 shall be employed if possible. Pneumatic testing may be used in lieu of hydrostatic testing only in accordance with the limitations in para. 937.4. Initial service testing may be used within the limitations of para. 937.5.

937.2 Preparation for Testing

937.2.1 Exposure of Joints. All joints including welds shall be left uninsulated and exposed for examination during the test.

937.2.2 Temporary Supports. Piping designed for vapor or gas may be provided with temporary supports if necessary to support the weight of test liquid.

937.2.3 Expansion Joints. Expansion joints that cannot sustain the reactions due to test pressure shall be provided with temporary restraint, or they may be isolated from testing.

937.2.4 Equipment Not Subject to Testing. Equipment that is not to be subjected to the test pressure shall be isolated from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.

937.2.5 Precautions Against Overpressure. If the test pressure is to be maintained for a period of time during which the test fluid is subject to thermal expansion or any other source of overpressurizing during the test, precautions such as the installation of a relief device shall be taken to avoid excessive pressure.

937.3 Hydrostatic Testing

937.3.1 Test Medium. Water at ambient temperature shall be used as the test medium except where there is

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risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping.

937.3.2 Vents and Drains. Vents shall be provided at high points in the system to release trapped air while filling the system. Drains shall be provided at low points for complete removal of the test liquid.

937.3.3 Preliminary Check. The system shall be examined to see that all equipment and parts that cannot withstand the test pressure are properly isolated. Test equipment shall be examined to ensure that it is tight and that low pressure filling lines are disconnected.

937.3.4 Hydrostatic Test Pressure

(a) Minimum Pressure. Except as limited in para. 937.3.4(b), a piping system shall be subjected to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure.

(b) Maximum Pressure. The test pressure shall not exceed the maximum test pressure for any vessel, pump, valve, or other component in the system under test. A check shall be made to verify that the stress due to pressure at the bottom of vertical runs does not exceed either of the following:

(1) 90% of specified minimum yield strength

(2) 1.7 times the *SE* value in Mandatory Appendix I (for brittle materials)

937.3.5 Examination for Leakage. Following the application of hydrostatic test pressure for at least 10 min, examination shall be made for leakage of the piping, and at all joints and connections. If leaks are found, they shall be eliminated by tightening, repair, or replacement, as appropriate, and the hydrostatic test repeated until no leakage is found.

937.4 Pneumatic Testing

937.4.1 General. Compressed gas poses the risk of sudden release of stored energy. For that reason, pneumatic testing shall be used only within the following limitations:

(a) The piping system does not contain cast iron pipe or plastic pipe subject to brittle failure.

(b) The system does not contain soldered or solvent cement joints over NPS 2 (DN 50).

(c) The test pressure does not exceed 150 psig (1 034 kPa).

(d) The system will be used in gas service, or for other reasons cannot be filled with water.

(e) Traces of a test liquid would be detrimental to the intended use of the piping.

937.4.2 Test Medium. The gas shall be nonflammable and nontoxic.

937.4.3 Preliminary Test. Prior to application of full pneumatic test pressure, a preliminary test of not more than 10 psig (69 kPa) shall be applied to reveal possible major leaks. (This preliminary test is not subject to the limitations in para. 937.4.1, and may be used in conjunction with hydrostatic testing or initial service testing.)

937.4.4 Pneumatic Test Pressure

(a) Except as limited in para. 937.4.4(b), the test pressure shall not exceed 1.25 times the design pressure. Pressure shall be applied in several stages, allowing time for the system to reach equilibrium at each stage.

(b) The test pressure shall not exceed the maximum allowable pneumatic test pressure for any vessel, pump, valve, or other component in the system under test.

937.4.5 Examination for Leakage. After the preliminary test, pressure shall be raised in stages of not more than 25% up to full pneumatic test pressure, allowing time for equalization of strains and detection of major leaks at each stage. Following the application of test pressure for at least 10 min, the pressure may be reduced to design pressure and examination shall be made for leakage of the piping. Leaks may be detected by soap bubble, halogen gas, scented gas, test gage monitoring, ultrasonic, or other suitable means. If leaks are found, pressure shall be vented, appropriate repair or replacement shall be made, and the pneumatic test repeated until no leakage is found.

937.5 Initial Service Leak Test

937.5.1 General. For gases and steam and condensate service not over 15 psig (103 kPa gage), and for nontoxic, noncombustible, nonflammable liquids at pressures not over 100 psig (689 kPa) and temperatures not over 200°F (93°C), it is permissible to conduct the system testing with the service fluid as outlined in para. 937.5.2.

937.5.2 Service Testing. A preliminary test with air at low pressure (para. 937.4.3) may be used. In any event, the piping system shall be brought up to operating pressure gradually with visual examination at a pressure between one-half and two-thirds of operating pressure. A final examination shall be made at operating pressure. If the piping system is free of leaks, it will have met the requirements of this paragraph. **(04)**

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MANDATORY APPENDIX I
STRESS TABLES

Table I-1 begins on next page.

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Table I-1 Allowable Stresses

Material	Spec. No.	Type or Grade	Class	P-No.	Notes	Factor *E* or *F*	Strengths: Min. Tensile, ksi	Strengths: Min. Yield, ksi	Max. Allowable Stress Value in Tension *SE*, ksi, for Metal Temperature, °F, Not Exceeding: 0 to 100	150	200	250	300	350	400
Carbon Steel															
Seamless Pipe and Tube															
...	ASTM A 53	A	S	1	...	1.00	48.0	30.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
...	ASTM A 53	B	S	1	...	1.00	60.0	35.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
...	ASTM A 106	A	...	1	...	1.00	48.0	30.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
...	ASTM A 106	B	...	1	...	1.00	60.0	35.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
...	API 5L	A	...	1	(1)	1.00	48.0	30.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
...	API 5L	B	...	1	(1)	1.00	60.0	35.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Butt Welded Pipe and Tube															
...	ASTM A 53	...	F	1	(2)	0.60	48.0	30.0	7.2	7.2	7.2	7.2	7.2	7.2	7.2
...	API 5L	A25	...	1	(1)	0.60	45.0	25.0	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Electric Resistance Welded Pipe and Tube															
...	ASTM A 53	A	E	1	...	0.85	48.0	30.0	10.2	10.2	10.2	10.2	10.2	10.2	10.2
...	ASTM A 53	B	E	1	...	0.85	60.0	35.0	12.8	12.8	12.8	12.8	12.8	12.8	12.8
...	ASTM A 135	A	...	1	...	0.85	48.0	30.0	10.2	10.2	10.2	10.2	10.2	10.2	10.2
...	ASTM A 135	B	...	1	...	0.85	60.0	35.0	12.8	12.8	12.8	12.8	12.8	12.8	12.8
...	API 5L	A25	...	1	(1)	0.85	45.0	25.0	9.5	9.5	9.5	9.5	9.5	9.5	9.5
...	API 5L	A	...	1	(1)	0.85	48.0	30.0	10.2	10.2	10.2	10.2	10.2	10.2	10.2
...	API 5L	B	...	1	(1)	0.85	60.0	35.0	12.8	12.8	12.8	12.8	12.8	12.8	12.8
Spiral Welded Pipe and Tube															
...	ASTM A 211	A570–30	...	1	(3)	0.75	49.0	30.0	9.2	8.4	9.2	...	...	...	...
...	ASTM A 211	A570–33	...	1	(3)	0.75	52.0	33.0	9.8	9.9	9.8	...	...	...	...
...	ASTM A 211	A570–40	...	1	(3)	0.75	55.0	40.0	10.3	9.4	10.3	...	...	...	...

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Table I-1 Allowable Stresses (Cont'd)

Material	Spec. No.	Type or Grade	Class	P-No.	Notes	Factor *E* or *F*	Strengths: Min. Tensile, ksi	Strengths: Min. Yield, ksi	Max. Allowable Stress Value in Tension *SE*, ksi, for Metal Temperature, °F, Not Exceeding: 0 to 100	150	200	250	300	350	400
Carbon Steel (Cont'd)															
Forgings and Fittings															
...	ASTM A 105	...	...	1	...	...	70.0	36.0	17.5	17.5	17.5	17.5	17.5	17.5	17.5
...	ASTM A 181	60	...	1	...	...	60.0	30.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
...	ASTM A 181	70	...	1	...	...	70.0	36.0	17.5	17.5	17.5	17.5	17.5	17.5	17.5
...	ASTM A 234	WPB	...	1	...	1.00	60.0	35.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
...	ASTM A 234	WPC	...	1	...	1.00	70.0	40.0	17.5	17.5	17.5	17.5	17.5	17.5	17.5
Structurals (4)															
...	ASTM A 36	...	...	1	(1)(3)	...	58.0	36.0	12.6	12.6	12.6	12.6	12.6	12.6	12.6
Bolts, Nuts, and Studs															
...	ASTM A 307	B	...	...	...	...	55.0	...	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ductile Iron Pipe															
...	ASTM A 377	...	...	...	(1)(5)	...	...	...	...	...	...	...	...	...	...
Fittings and Couplings															
...	ASTM A 395	60–49–18	...	...	...	0.80	60.0	40.0	9.6	9.6	...	...	...	...	...
...	ASTM A 536	65–45–12	...	...	...	0.80	65.0	45.0	10.4	10.4	...	...	...	...	...
Stainless Steel															
Seamless Pipe and Tube															
18Cr–8Ni	ASTM A 312	S30400	...	8	...	1.00	75.0	30.0	16.0	...	13.3	...	12.0	...	11.0
18Cr–8Ni	ASTM A 312	S30400	...	8	(6)	1.00	75.0	30.0	16.0	...	15.1	...	14.1	...	13.8
18Cr–8Ni	ASTM A 312	S30403	...	8	(1)	1.00	70.0	25.0	13.3	...	11.4	...	10.2	...	9.3
18Cr–8Ni	ASTM A 312	S30403	...	8	(1)(6)	1.00	70.0	25.0	13.3	...	13.3	...	13.0	...	12.5
16Cr–12Ni–2Mo	ASTM A 312	S31600	...	8	...	1.00	75.0	30.0	16.0	...	13.8	...	12.4	...	11.4
16Cr–12Ni–2Mo	ASTM A 312	S31600	...	8	(6)	1.00	75.0	30.0	16.0	...	16.0	...	15.6	...	15.4
16Cr–12Ni–2Mo	ASTM A 312	S31603	...	8	(1)	1.00	70.0	25.0	13.3	...	11.3	...	10.1	...	9.2
16Cr–12Ni–2Mo	ASTM A 312	S31603	...	8	(1)(6)	1.00	70.0	25.0	13.3	...	13.3	...	13.3	...	13.2
18Cr–13Ni–3Mo	ASTM A 312	S31700	...	8	(1)	1.00	75.0	30.0	16.0	...	13.8	...	12.4	...	11.4
18Cr–13Ni–3Mo	ASTM A 312	S31700	...	8	(1)(6)	1.00	75.0	30.0	16.0	...	16.0	...	15.6	...	15.4

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Table I-1 Allowable Stresses (Cont'd)

Material and Spec. No.	Alloy	Temper	Size or Thickness, in.	P–No.	Notes	Strengths: Min. Tensile, ksi	Strengths: Min. Yield, ksi	Max. Allowable Stress Value in Tension *SE*, ksi, for Metal Temperature, °F, Not Exceeding: 0 to 100	150	200	250	300	350	400
Aluminum and Aluminum Alloys														
Drawn Seamless Pipe and Tubes														
ASTM B 210	3003	O	0.010–0.500	21	(1)	14.0	5.0	3.4	3.4	3.4	3.0	2.4	1.8	1.4
ASTM B 210	3003	H14	0.010–0.500	21	(1)(7)	20.0	17.0	5.0	5.0	5.0	4.9	4.3	3.0	2.4
ASTM B 210	5050	O	0.018–0.500	21	(1)	18.0	6.0	4.0	4.0	4.0	4.0	4.0	2.8	1.4
ASTM B 210	6061	T4	0.025–0.500	21	(1)(8)	30.0	16.0	7.5	7.5	7.5	7.4	6.9	6.3	4.5
ASTM B 210	6061	T6	0.025–0.500	21	(1)(8)	42.0	35.0	10.5	10.5	10.5	9.9	8.4	6.3	4.5
ASTM B 210	6061	T4, T6	0.025–0.500	21	Welded;(1)(9)	24.0	. . .	6.0	6.0	6.0	5.9	5.5	4.6	3.5
Seamless Pipe and Seamless Extruded Tube														
ASTM B 241	3003	O	All	21	(1)	14.0	5.0	3.4	3.4	3.4	3.0	2.4	1.8	1.4
ASTM B 241	3003	H18	< 1	21	(1)(7)	27.0	24.0	6.8	6.8	6.7	6.3	5.4	3.5	2.5
ASTM B 241	3003	H112	All	21	(1)(7)	14.0	5.0	3.3	3.3	3.3	3.0	2.4	1.8	1.4
ASTM B 241	5083	O	Up thru 5.000	25	(1)(10)	39.0	16.0	9.8	9.8	. . .	. . .	. . .	. . .	. . .
ASTM B 241	5083	H112	Up thru 5.000	25	(1)(10)	39.0	16.0	9.8	9.8	. . .	. . .	. . .	. . .	. . .
ASTM B 241	6061	T4	All	23	(1)(8)(11)	26.0	16.0	6.5	6.5	6.5	6.4	6.0	5.8	4.5
ASTM B 241	6061	T6	All	23	(1)(8)(11)	38.0	35.0	9.5	9.5	9.5	9.1	7.9	6.3	4.5
ASTM B 241	6061	T4, T6	All	23	Welded; (1)(9)(11)	24.0	. . .	6.0	6.0	6.0	5.9	5.5	4.6	3.5
ASTM B 241	6063	T6	All	23	(1)(8)	30.0	16.0	7.5	7.5	7.4	6.8	5.0	3.4	2.0
ASTM B 241	6063	T5, T6	All	23	Welded; (1)(9)	17.0	. . .	4.3	4.3	4.3	4.2	3.9	3.0	2.0

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Table I-1 Allowable Stresses (Cont'd)

Material	Spec. No.	Alloy No.	Condition	P–No.	Notes	Strengths: Min. Tensile, ksi	Strengths: Min. Yield, ksi	Max. Allowable Stress Value in Tension *SE*, ksi, for Metal Temperature, °F, Not Exceeding: 0 to 100	150	200	250	300	350	400
Copper and Copper Alloys														
Seamless Pipe and Tube														
Copper Pipe, Size range NPS 1/8–2 incl	ASTM B 42	102, 122	Annealed	31	. . .	30.0	9.0	6.0	5.1	4.8	4.8	4.7	4.0	3.0
Copper Pipe, Size range NPS 1/8–2 incl	ASTM B 42	102, 122	Hard drawn	31	(12)	45.0	40.0	11.3	11.3	11.3	11.3	11.0	10.3	4.3
Copper Pipe, Size range NPS 2 1/2–12 incl	ASTM B 42	102, 122	Light drawn	31	(12)	36.0	30.0	9.0	9.0	9.0	9.0	8.7	8.5	8.2
Red Brass Pipe	ASTM B 43	230	Annealed	32	. . .	40.0	12.0	8.0	8.0	8.0	8.0	8.0	7.0	5.0
Copper Tube	ASTM B 68	102, 122	Annealed	. . .	(1)	30.0	9.0	6.0	6.0	5.9	5.8	5.0	3.8	2.5
Copper Tube	ASTM B 75	102, 122	Annealed	31	. . .	30.0	9.0	6.0	5.1	4.8	4.8	4.7	4.0	3.0
Copper Tube	ASTM B 75	102, 122	Light drawn	31	(12)	36.0	30.0	9.0	9.0	9.0	9.0	8.7	8.5	8.2
Copper Tube	ASTM B 75	102, 122	Hard drawn	31	(12)	45.0	40.0	11.3	11.3	11.3	11.3	11.0	10.3	4.3
Copper Tube	ASTM B 88	102, 122	Annealed	. . .	(1)	30.0	9.0	6.0	5.1	4.8	4.8	4.7	4.0	3.0
Copper Tube	ASTM B 88	102, 122	Drawn	. . .	(1)(12)	36.0	30.0	9.0	9.0	9.0	9.0	8.7	8.5	8.2
Brass Tube	ASTM B 135	230	Annealed	32	. . .	40.0	12.0	8.0	8.0	8.0	8.0	8.0	7.0	5.0
Copper Tube	ASTM B 280	102, 122	Annealed	. . .	(1)	30.0	9.0	6.0	5.1	4.8	4.8	4.7	4.0	3.0
Copper Pipe, Threadless	ASTM B 302	102, 122	Drawn	. . .	(1)	36.0	30.0	9.0	9.0	9.0	9.0	8.7	8.5	8.2

GENERAL NOTES:

(a) See para. 902.3 for discussion of allowable stress values.

(b) The tabulated specifications are ASTM, except as noted. For boiler external piping, the corresponding ASME specifications shall be used. See Section II of the ASME BPV Code.

(c) The stress values may be interpolated to determine allowable stresses for intermediate temperatures.

(d) The P-Numbers indicated in this Appendix are identical to those adopted in Section IX of the ASME BPV Code.

(e) All stress values are shown in units of thousands of pounds-force per square in. (ksi). Multiply by 1000 to obtain values in psi.

(f) Materials listed in Table 926.1 for which allowable stress values are not tabulated in Appendix I may be used at allowable stresses found in ASME B31.1 or in Section I or Section VIII, Division 1 of the ASME BPV Code. However, the temperature limits in this Code shall apply.

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Table I-1 Allowable Stresses (Cont'd)

NOTES:

(1) This material is not acceptable for boiler external piping. See Fig. 900.1.2B.

(2) ASTM A 53 Type F pipe shall not be used for flammable or toxic fluids.

(3) These stress values include a quality factor of 0.92 for structural material used in fabricating pressure containing components. Materials used in supports shall have an allowable stress value in tension of one-fifth the specified minimum tensile strength.

(4) Materials such as pipe listed elsewhere in Mandatory Appendix I may be used as structural material in accordance with para. 921.

(5) The specification provides wall thicknesses appropriate to the various diameters and combinations of pressure and laying condition. See ANSI/AWWA C150/A 21.50, Manual for the Thickness Design of Ductile Iron Pipe.

(6) Due to the relatively low yield strength of these materials, these higher stress values were established for use at temperatures where the short-time tensile properties govern, in order to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed $62\frac{1}{2}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

(7) The stress values given for this material are not applicable when either welding or thermal cutting is employed; in such cases, use the value for O temper.

(8) The stress values for this material are not applicable when either welding or thermal cutting is employed; in such cases, use the values for the welded condition.

(9) Strength of reduced-section tensile specimen is required to quality welding procedure. See the ASME BPV Code, Section IX, QW-150.

(10) The supplier of material shall be consulted as to the ability of the alloy to withstand stress corrosion cracking under design conditions and combinations of stress and corrosive environments.

(11) For stress-relieved tempers (T351, T3510, T3511, T451, T4510, T4511, T651, T6510, T6511), stress values for material in the basic temper shall be used.

(12) Where brazed construction is employed, stress values for the annealed condition shall be used.

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Table I-2 Hydrostatic Design Stresses (HDS) and Recommended Temperature Limits For Thermoplastic Pipe

ASTM Spec. No.	Material	Recommended Temperature Limits [Notes (1), (2)] Minimum, °F	Maximum, °F	Hydrostatic Design Stress at 73°F, ksi [Note (3)]	100°F, ksi	180°F, ksi
D 1527, D 2282, D 2513	ABS1210	−30	180	1.0	0.8	...
	ABS1316	−30	180	1.6	1.25	...
	ABS2112	−30	180	1.25	1.0	...
D 2846, F 441, F 442	CPVC4120	0	210	2.0	1.6	0.5
D 2513, D 2662, D 2666, D 3000, D 3309	PB2110	0	210	1.0	0.8	0.5
D 2104, D 2239, D 2447, D 2513, D 2737, D 3035	PE2306	−30	140	0.63	0.4	...
	PE3306	−30	160	0.63	0.5	...
	PE3406	−30	180	0.63	0.5	...
	PE3408	−30	180	0.80	0.5	...
...	PP	30	210	...	...	...
D 1785, D 2241, D 2513, D 2672	PVC1120	0	150	2.0	1.6	...
	PVC1220	0	150	2.0	1.6	...
	PVC2110	0	130	1.0	0.8	...
	PVC2120	0	150	2.0	1.6	...

NOTES:

(1) These recommended limits are for low pressure applications with water and other fluids that do not significantly affect the properties of the thermoplastic. The upper temperature limits are reduced at higher pressures, depending on the combination of fluid and expected service life. Lower temperature limits are affected more by the environment, safeguarding, and installation conditions than by strength.

(2) These recommended limits apply only to materials listed. Manufacturers should be consulted for temperature limits on specific types and kinds of materials not listed.

(3) Use these hydrostatic design stress (HDS) values at all lower temperatures.

Table I-3 Design Stress Values For Contact Molded (Hand-Lay-Up) Pipe Made From Reinforced Thermosetting Resins

Material Spec. No.	Resin	Reinforcing	Thickness, in.	Stress Values, psi [Note (1)]
ASTM C 582	Polyester	Glass fiber	$\frac{1}{8} - \frac{3}{16}$	900
			$\frac{1}{4}$	1 200
			$\frac{5}{16}$	1 350
			$\geq \frac{3}{8}$	1 500

NOTE:

(1) Stress values apply in the range −20°F to 180°F.

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Table I-4 Hydrostatic Design Basis Stress for Machine-Made Thermosetting Resin Pipe

ASTM Spec. No. and Type	Grade	Class	Material Designation Number (ASTM 2310)	Hoop Stress, psi — Hydrostatic Design Basis 73°F, [Note (1)]	
				Cyclic [Note (2)]	Static [Note (3)]
D 2517 filament wound	Glass-fiber reinforced epoxy resin, gas pressure pipe	No liner	RTRP-11AD	5,000	. . .
			RTRW-11AW	. . .	16,000
D 2996 filament wound	Glass-fiber reinforced epoxy resin	No liner	RTRP-11AD	5,000	. . .
			RTRP-11AW	. . .	16,000
		Epoxy resin liner, reinforced	RTRP-11FE	6,300	. . .
			RTRP-11FD	5,000	. . .
	Glass-fiber reinforced polyester resin	Polyester resin liner reinforced	RTRP-12EC	4,000	. . .
			RTRP-12ED	5,000	. . .
			RTRP-12EU	. . .	12,500
		No liner	RTRP-12AD	5,000	. . .
			RTRP-12AU	. . .	12,500
D 2997 centrifugally cast	Glass-fiber reinforced polyester resin	Polyester resin liner reinforced	RTRP-22BT	. . .	10,000
			RTRP-22BU	. . .	12,500
		Epoxy resin liner, nonreinforced	RTRP-21CT	. . .	10,000
			RTRP-21CU	. . .	12,500

NOTES:
(1) Service (design) factor must be applied to these values to obtain a hydrostatic design stress.
(2) When using the cyclic design basis, the service factor shall not exceed 1.0.
(3) When using the static design basis, the service factor shall not exceed 0.5.

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MANDATORY APPENDIX II
ALLOWABLE PRESSURES FOR NONMETALLIC, NONPLASTIC PRESSURE PIPING

Table II-1 Alowable Pressures For Nonmetallic, Nonplastic Pressure Piping

Spec. No.	Material	Class	Allowable Gage Pressure, psi	Maximum Temperature, °F
ASTM C 361	Reinforced concrete low head pressure pipe	25 ft	10	...
		50 ft	20	...
		75 ft	30	...
		100 ft	40	...
		125 ft	50	...
AWWA C 300	Reinforced concrete water pipe, steel cylinder type	...	260	...
AWWA C 301	Prestressed concrete pressure pipe, steel cylinder type, for water and other liquids	Lined cylinder	250	...
		Embedded cylinder	350	...
AWWA C 302	Reinforced concrete water pipe, noncylinder type	...	45	...

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MANDATORY APPENDIX III
REFERENCE STANDARDS

Specific editions of standards incorporated in this Code by reference and the names and addresses of the sponsoring organizations are shown in this Appendix. This Appendix will be revised as needed. The names and addresses of the sponsoring organizations are also shown in this Appendix. An asterisk (*) indicates that the standard has been approved as an American National Standard by the American National Standards Institute (ANSI).

AGA
*A21.14–84
*A21.52–82
*Z223.1–92

API
5L, 38th Ed., 1992
594, 3rd Ed., 1993
609, 3rd Ed., 1993

ASME
*B1.1–89
& B1.1a-84
*B1.20.1–83(R92)
*B1.20.3–76(R82)
*B1.20.7–91
*B16.1–89
*B16.3–92
*B16.4–92
*B16.5–88
*B16.9–93
*B16.10–92
*B16.11–91
*B16.14–91
*B16.15–85
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CDA
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GENERAL NOTE: In general, the issue date shown immediately following the hyphen after the number of the standard (e.g., B16.10–73, A47–84, J514–80) is the effective date of the issue (edition) of the standard. Any additional number shown following the issue date and prefixed by the letter "R" is the latest date of reaffirmation [e.g., B1.20.3–76(R82), D1503–73(R78)].

A component or pipe conforming to an earlier material specification edition purchased by the user prior to the date of issuance of this Edition of the Code may be used, provided the component or pipe is inspected and determined to be satisfactory for the service intended.

NOTE:
(1) Out-of-print.

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Specifications and standards of the following organizations appear in this Appendix:

AGA American Gas Association
400 N. Capitol St., NW, Suite 450
Washington, D.C. 20001
202 824-7000

API American Petroleum Institute
Publications and Distribution Section
1220 L Street, N.W.
Washington, D.C. 20005
202 682-8375

ASME The American Society of Mechanical Engineers
Order Department
22 Law Drive, P.O. Box 2300
Fairfield, New Jersey 07007-2300
201 882-1167

ASTM American Society for Testing and Materials
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959
610 832-9585

AWS American Welding Society
550 N.W. LeJeune Road
Miami, Florida 33126
800 443-9353

AWWA American Water Works Association
6666 W. Quincy Avenue
Denver, Colorado 80235
303 794-7711

. . . Federal Specifications: Superintendent of Documents
United States Government Printing Office
Washington, D.C. 20402
202 783-3238

CDA Copper Development Association, Inc.
260 Madison Avenue
New York, New York 10016
212 251-7200

MSS Manufacturers Standardization Society of the Valve and Fittings Industry
127 Park Street, N.E.
Vienna, Virginia 22180
703 281-6613

NFPA National Fire Protection Association
1 Batterymarch Park
Quincy, Massachusetts 02169
617 770-3000

SAE Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, Pennsylvania 15096
724 776-4841

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MANDATORY APPENDIX IV
PREPARATION OF TECHNICAL INQUIRIES

IV-1 INTRODUCTION

The ASME B31 Committee, Code for Pressure Piping, will consider written requests for interpretations and revisions of the Code rules, and develop new rules if dictated by technological development. The Committee's activities in this regard are limited strictly to interpretations of the rules or to the consideration of revisions to the present rules on the basis of new data or technology. As a matter of published policy, ASME does not approve, certify, rate, or endorse any item, construction, proprietary device, or activity, and, accordingly, inquiries requiring such consideration will be returned. Moreover, ASME does not act as a consultant on specific engineering problems or on the general application or understanding of the Code rules. If, based on the inquiry information submitted, it is the opinion of the Committee that the inquirer should seek professional assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

Inquiries that do not provide the information needed for the Committee's full understanding will be returned.

The Introduction to this Code states, "It is the owner's responsibility to select the Code Section that most nearly applies to a proposed piping installation." The Committee will not respond to inquiries requesting assignment of a Code Section to a piping installation.

IV-2 REQUIREMENTS

Inquiries shall be limited strictly to interpretations of the rules or to the consideration of revisions to the present rules on the basis of new data or technology. Inquiries shall meet the following requirements:

(a) Scope. Involve a single rule or closely related rules in the scope of the Code. An inquiry letter concerning unrelated subjects will be returned.

(b) Background. State the purpose of the inquiry, which would be either to obtain an interpretation of Code rules, or to propose consideration of a revision to the present rules. Provide concisely the information needed for the Committee's understanding of the inquiry, being sure to include reference to the applicable Code Section, Edition, Addenda, paragraphs, figures, and tables. If sketches are provided, they shall be limited to the scope of the inquiry.

(c) Inquiry Structure

(1) Proposed Question(s). The inquiry shall be stated in a condensed and precise question format, omitting superfluous background information, and, where appropriate, composed in such a way that "yes" or "no" (perhaps with provisos) would be an acceptable reply. The inquiry statement should be technically and editorially correct.

(2) Proposed Reply(ies). Provide a proposed reply stating what it is believed that the Code requires.

If in the inquirer's opinion a revision to the Code is needed, recommended wording shall be provided in addition to information justifying the change.

IV-3 SUBMITTAL

Inquiries should be submitted in typewritten form; however, legible handwritten inquiries will be considered. They shall include the name and mailing address of the inquirer, and be mailed to the following address:

Secretary
ASME B31 Committee
Three Park Avenue
New York, NY 10016-5990

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NONMANDATORY APPENDIX A
NONMANDATORY QUALITY SYSTEM PROGRAM[1]

Organizations performing Design, Fabrication, Assembly, Erection, Inspection, Examination, Testing, Installation, Operation, and Maintenance for B31.9 piping systems shall have a written Quality System in accordance with applicable ISO 9000 Series documents. Registration or certification of the Quality System shall be by agreement between contracting parties involved.

(a) ISO 9000-1:1994. Quality Management and Quality Assurance Standards — Part 1: Guidelines for Selection and Use

(b) ISO 9000-2: 1993. Quality Management and Quality Assurance Standards — Part 2: Generic Guidelines for the Application of ISO 9001, ISO 9002, and ISO 9003

(c) ISO 9000-3:1991. Quality Management and Quality Assurance Standards — Part 3: Guidelines for the Application of ISO 9001 to the Development, Supply, and Maintenance of Software

(d) ISO 9001:1994. Quality Systems — Model for Quality Assurance in Design, Development, Production, Installation, and Servicing

(e) ISO 9002:1994. Quality Systems — Model for Quality Assurance in Production and Servicing

(f) ISO 9003:1994. Quality Systems — Model for Quality Assurance in Final Inspection and Test

[1] See para. 936.1.1.

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ASME B31.9 INTERPRETATIONS

Replies to Technical Inquiries
April 2001 Through December 2002

Foreword

It has been agreed to publish interpretations isssued by the B31 Committee concerning B31.9 as part of the update service to the Code. The interpretations have been assigned numbers in chronological order. Each interpretation applies to the latest Edition or Addenda at the time of issuance of the interpretation or the Edition or Addenda stated in the reply. Subsequent revisions to the Code may have superseded the reply. **The interpretations are not part of the Code or its Addenda.**

These replies are taken verbatim from the original letters, except for a few typographical and editorial corrections made for the purpose of improved clarity. In some instances, a review of the interpretation revealed a need for corrections of a technical nature. In these cases, a revised reply, bearing the original interpretation number with the suffix R, is presented. In the case where an interpretation is corrected by Errata, the original interpretation number with the suffix E is used.

ASME procedures provide for reconsideration of these interpretations when or if additional information is available which the inquirer believes might affect the interpretation. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME committee or subcommittee. As stated in the Statement of Policy in the Code documents, ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

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Interpretation: 9-9

Subject: Acceptance Standards for Weld Flaws in Para. 936.6 (1996 Edition)

Date Issued: April 18, 2001

File: B31-01-013

Question (1): The last sentence of para. 936.6 includes acceptance standards for weld flaws that are detectable by methods other than by visual examination. What additional examination is required in order to detect such flaws?

Reply (1): None. The only examination required by this Code is visual. If any additional examinations are to be used, they must be specified in the engineering design, and they must be a matter of prior agreement between the fabricator or installer and the purchaser. The acceptance criteria are to be in accordance with para. 936.6 unless other acceptance criteria are provided in the engineering design.

Interpretation: 9-10

Subject: Incomplete Penetration in Para. 936.6.1(c) of B31.9 (1996 edition)

Date Issued: May 29, 2001

File: B31-01-012

Background: A butt weld on NPS 6, Schedule 40 (0.280 wall) pipe was visually examined, and incomplete penetration was discovered on the root of the weld.

Question (1): Is incomplete penetration that is shorter than $1\frac{1}{2}$ in. in length but more than $\frac{1}{32}$ in. in depth acceptable per para. 936.6.1(c)?

Reply (1): No.

Question (2): Is incomplete penetration that is longer than $1\frac{1}{2}$ in. in length but less than $\frac{1}{32}$ in. in depth acceptable per para. 936.6.1(c)?

Reply (2): No.

Interpretation: 9-11

Subject: Lack of Fusion and Incomplete Penetration Requirements in B31.9 (1996 Edition)

Date Issued: August 2, 2001

File: B31-01-032

Question: Does B31.9 allow any lack of fusion or incomplete penetration in a CJP groove weld on pipe without backing?

Reply: Yes. See paras. 936.6.1(b) and (c).

Interpretation: 9-12

Subject: Use of Concentric Tubes in Tube Heat Exchangers (1996 Edition)

Date Issued: December 5, 2002

File: 02-03544

Question: Does a heat exchanger consisting of concentric tubes fall within the scope of ASME B31.9?

Reply: No.

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