

ASME B31.1-2018
(Revision of ASME B31.1-2016)

Power Piping

ASME Code for Pressure Piping, B31

AN INTERNATIONAL PIPING CODE®



**The American Society of
Mechanical Engineers**

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**The American Society of
Mechanical Engineers**

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FOREWORD

The general philosophy underlying this Power Piping Code is to parallel those provisions of Section I, Power Boilers, of the ASME Boiler and Pressure Vessel Code, as they can be applied to power piping systems. The Allowable Stress Values for power piping are generally consistent with those assigned for power boilers. This Code is more conservative than some other piping codes, reflecting the need for long service life and maximum reliability in power plant installations.

The Power Piping Code as currently written does not differentiate among the design, fabrication, and erection requirements for critical and noncritical piping systems, except for certain stress calculations and mandatory nondestructive tests of welds for heavy wall, high temperature applications. The problem involved is to try to reach agreement on how to evaluate criticality, and to avoid the inference that noncritical systems do not require competence in design, fabrication, and erection. Someday such levels of quality may be definable, so that the need for the many different piping codes will be overcome.

There are many instances where the Code serves to warn a designer, fabricator, or erector against possible pitfalls; but the Code is not a handbook, and cannot substitute for education, experience, and sound engineering judgment.

Nonmandatory Appendices are included in the Code. Each contains information on a specific subject, and is maintained current with the Code. Although written in mandatory language, these Appendices are offered for application at the user's discretion.

The Code never intentionally puts a ceiling limit on conservatism. A designer is free to specify more-rigid requirements as he/she feels they may be justified. Conversely, a designer who is capable of applying a more complete and rigorous analysis consistent with the design criteria of this Code may justify a method different than specified in the Code, and still satisfy the Code requirements.

The Power Piping Committee strives to keep abreast of the current technological improvements in new materials, fabrication practices, and testing techniques; and endeavors to keep the Code updated to permit the use of acceptable new developments.

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Code for Pressure Piping

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A. A. Hassan, Power Generation Engineering and Services Co.
L. Henderson, Jr., Chiyoda International Corp.

C. Henley, Kiewit Engineering Group, Inc.
G. Jolly, Samshin Limited
C. J. Melo, TechnipFMC
M. L. Nayyar, NICE
D. W. Raho, CCM 2000
R. A. Schmidt, Canadoil
Z. Djilali, *Contributing Member*, Sonatrach
J. L. Smith, *Contributing Member*

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T. Q. McCawley, TQM Engineering
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A. Paulin, Paulin Research Group
R. A. Robleto, KBR
M. J. Rosenfeld, Kiefner/Applus — RTD
T. Sato, Japan Power Engineering and Inspection Corp.
M. Stewart, AECOM

INTRODUCTION

The ASME B31 Code for Pressure Piping consists of a number of individually published Sections, each an American National Standard, under the direction of ASME Committee B31, Code for Pressure Piping.

Rules for each Section have been developed considering the need for application of specific requirements for various types of pressure piping. Applications considered for each Code Section include

- B31.1 Power Piping: piping typically found in electric power generating stations, in industrial and institutional plants, geothermal heating systems, and central and district heating and cooling systems
- B31.3 Process Piping: piping typically found in petroleum refineries; chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants; and related processing plants and terminals
- B31.4 Pipeline Transportation Systems for Liquids and Slurries: piping transporting products that are predominately liquid between plants and terminals and within terminals, pumping, regulating, and metering stations
- B31.5 Refrigeration Piping and Heat Transfer Components: piping for refrigerants and secondary coolants
- B31.8 Gas Transmission and Distribution Piping Systems: piping transporting products that are predominately gas between sources and terminals, including compressor, regulating, and metering stations; and gas gathering pipelines
- B31.9 Building Services Piping: piping typically found in industrial, institutional, commercial, and public buildings, and in multi-unit residences, which does not require the range of sizes, pressures, and temperatures covered in B31.1
- B31.12 Hydrogen Piping and Pipelines: piping in gaseous and liquid hydrogen service, and pipelines in gaseous hydrogen service

This is the B31.1 Power Piping Code Section. Hereafter, in this Introduction and in the text of this Code Section B31.1, where the word *Code* is used without specific identification, it means this Code Section.

It is the owner's responsibility to select the Code Section that most nearly applies to a proposed piping 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. For some installations, more than one Code Section may apply to different parts of the installation. The owner is also responsible for imposing requirements supplementary to those of the selected Code Section, if necessary, to assure safe piping for the proposed installation.

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

- ASME Boiler and Pressure Vessel Code, Section III: nuclear power piping
- ANSI Z223.1/NFPA 54 National Fuel Gas Code: piping for fuel gas from the point of delivery to the connection of each fuel utilization device
- NFPA Fire Protection Standards: fire protection systems using water, carbon dioxide, halon, foam, dry chemicals, and wet chemicals
- NFPA 85 Boiler and Combustion Systems Hazards Code
- building and plumbing codes, as applicable, for potable hot and cold water, and for sewer and drain systems

The Code specifies engineering requirements deemed necessary for safe design, construction, operation, and maintenance of pressure piping. While safety is the overriding consideration, this factor alone will not necessarily govern the final specifications for any piping installation or operation. The Code is not a design handbook. Many decisions that must be made to produce a safe piping installation and to maintain system integrity are not specified in detail within this Code. The Code does not serve as a substitute for sound engineering judgment by the owner and the designer.

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

The Code generally specifies a simplified approach for many of its requirements.

For design and construction, a designer may choose to use a more-rigorous analysis to develop design and construction requirements. When the designer decides to take this approach, the designer shall provide to the owner details and calculations demonstrating that design, construction, examination, and testing are consistent with the criteria of the Code. These details shall be adequate for the owner to verify the validity of the approach and shall be approved by the owner. The details shall be documented in the engineering design.

For operation and maintenance, an owner may choose to use a more-rigorous approach to develop operation and maintenance requirements. When the owner decides to take this approach, the owner shall provide details and calculations demonstrating that such alternative practices are consistent with the general philosophy of the Code. The details shall be documented in the operating records and retained for the lifetime of the facility.

This Code Section includes the following:

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

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

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

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

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

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

(g) requirements for operation and maintenance of piping systems

It is intended that this edition of Code Section B31.1 not be retroactive. Unless agreement is specifically made between contracting parties to use another issue, or the regulatory body having jurisdiction imposes the use of another issue, the latest edition issued at least 6 months prior to the original contract date for the first phase of activity covering a piping system or systems shall be the governing document for all design, materials, fabrication, erection, examination, and testing for the piping until the completion of the work and initial operation.

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

Code users will note that clauses in the Code are not necessarily numbered consecutively. Such discontinuities result from following a common outline, insofar as practicable, for all Code Sections. In this way, corresponding material is correspondingly numbered in most Code

Sections, thus facilitating reference by those who have occasion to use more than one Section.

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

When no Section of the ASME Code for Pressure Piping specifically covers a piping system, at the user's discretion, he/she may select any Section determined to be generally applicable. However, it is cautioned that supplementary requirements to the Section chosen may be necessary to provide for a safe piping system for the intended application. Technical limitations of the various Sections, legal requirements, and possible applicability of other codes or standards are some of the factors to be considered by the user in determining the applicability of any Section of this Code.

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 H](#) covering preparation of technical inquiries). The Committee will not respond to inquiries requesting assignment of a Code Section to a piping installation.

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. The Case will be published as part of a Case Supplement issued to the applicable Code Section.

The ASME B31 Standards Committee took action to eliminate Code Case expiration dates effective September 21, 2007. This means that all Code Cases in effect as of this date will remain available for use until annulled by the ASME B31 Standards Committee.

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. Additional criteria can be found in the guidelines for addition of new materials in ASME Boiler and Pressure Vessel Code, Section II. (To develop usage and gain experience, unlisted materials may be used in accordance with [para. 123.1.](#))

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

ASME B31.1-2018 SUMMARY OF CHANGES

Following approval by the ASME B31 Committee and ASME, and after public review, ASME B31.1-2018 was approved by the American National Standards Institute on June 27, 2018.

ASME B31.1-2018 includes the following changes identified by a margin note, **(18)**. In addition, the paragraph break-downs and many of the figures and tables have been editorially redesignated in accordance with ASME Codes and Standards' editorial style. For the user's convenience, a table listing the former and current figure and table designations follows this Summary of Changes.

<i>Page</i>	<i>Location</i>	<i>Change</i>
xii	Introduction	(1) Sixth and eighth paragraphs revised (2) Ninth and tenth paragraphs added
1	100.1.1	First paragraph revised
1	100.1.2	In subparagraph (a), third and fourth paragraphs revised
2	100.1.4	Revised
2	100.2	(1) Definitions of <i>austenitizing</i> ; <i>heat treatments, subcritical heat treatment</i> ; and <i>heat treatments, tempering</i> added (2) Definitions of <i>covered piping systems (CPS)</i> , <i>failure, heat treatments, reinforcement of weld, repair, and undercut</i> revised
3	Figure 100.1.2-1	Title and illustration revised
4	Figure 100.1.2-2	Title and illustration revised
5	Figure 100.1.2-3	Revised
6	Figure 100.1.2-4	Revised
7	Figure 100.1.2-5	Title and illustration revised
8	Figure 100.1.2-6	Cross-references added to illustration
9	Figure 100.1.2-7	Added
16	101.7.2	Revised
19	102.4.5	Subparagraph (b) revised
22	104.1	(1) Paragraph 104.1.1 revised (2) In subparagraph 104.1.2(a), equations revised, nomenclature alphabetized, and <i>W</i> added (3) Paragraph 104.1.4 deleted
27	Figure 104.3.1-1	In General Note (b), d_t corrected by errata to read d_1
35	104.8.2	Revised
35	104.8.4	Subparagraph (c) revised
36	106.1	Subparagraph (a) punctuation revised
67	123.1.1	Subparagraph (c) revised
69	124.2	(1) Subparagraphs (a) and (b) revised (2) Subparagraph (e) added
70	125.1	Title revised

70	125.1.2	Subparagraphs (a) and (c) revised
71	125.1.3	Subparagraph (c) revised
73	Table 126.1-1	(1) For ASCE/SEI 7 and ASME B31J, titles revised (2) ASTM A1091/A1091M and Standards of the Expansion Joint Manufacturers Association, Inc. added (3) FCI 79-1 revised
85	Table 127.4.2-1	Revised
93	129.3.3.1	First paragraph revised
93	129.3.4	Revised
93	129.3.4.1	First paragraph revised
94	Table 129.3.3.1-1	Title revised
96	Table 129.3.4.1-1	Title revised
97	Table 131.4.1-1	(1) In fifth column, first entry revised
98	Table 132.1.1-1	(1) In second column, penultimate entry revised (2) Notes (5) and (6) revised
99	132.4	Title revised
104	136.1.1	Revised
104	136.1.2	Subparagraph (a) revised
104	136.2	Revised in its entirety
105	136.3.2	(1) Subparagraph (d) revised (2) Last paragraph revised
108	136.4.6	Subparagraph (c) added
118	Table A-1	Note (1) revised
130	Table A-2	(1) Under Electric Fusion Welded Pipe — Filler Metal Added, Notes revised for first 12 entries (2) Under Castings, A1091 C91 added (3) Notes (1) and (2) revised
142	Table A-3	(1) Under Seamless Pipe and Tube, Austenitic, for both A312 TP321 lines and second TP321H line, Notes revised (2) Second group of A312 TP321 and TP321H lines added (3) Under Ferritic/Austenitic, A789 and A790 S32003 added (4) Under Welded Pipe and Tube — Without Filler Metal, Ferritic/Austenitic, A789 and A790 S32003 added (5) Under Welded Pipe and Tube — Filler Metal Added, Ferritic/Austenitic, for first entry, UNS No. and Specified Minimum Tensile revised (6) Under Pipe, Sheet, and Strip, Ferritic/Austenitic, two A240 S32003 lines added (7) Notes (1) and (24) revised (8) Notes (30) and (31) added
176	Table A-4	(1) Note (1) reference deleted from 71 lines (2) Note (1) revised
190	Table A-5	(1) For A395 60-40-18, stress value for 600°F corrected by errata to read 9.0 (2) Note (1) revised
194	Table A-6	Note (1) revised
200	Table A-7	Note (1) revised

210	Table A-8	(1) Under Seamless Pipe and Tube, for first A312 TP321H line, Notes revised (2) Second A312 TP321H line added (3) Note (1) revised (4) Notes (8) and (9) added
218	Table A-9	Note (1) revised
222	Table A-10	Notes (2) and (14) revised
247	Table D-1	General Note (b) added
254	Mandatory Appendix F	(1) Editions revised (2) ASTM A1091/A1091M; ASME CA-1 and QAI-1; Standards of the EJMA, Inc.; and NFPA 56 added (3) AISC address updated and EJMA added
258	Mandatory Appendix G	(1) Last h , ℓ , P_o , and last S added (2) For NPS, reference corrected by errata to read 100.1.2 (3) References for P and W updated (4) For S_E and SE , reference to para. 102.3.2(b) relocated by errata (5) For S_L , reference corrected by errata to read 102.3.2(a)(3)
265	Mandatory Appendix J	Deleted
267	N-100.2.1	Definition of <i>winding angle</i> added
269	Figure N-100.2.1-1	Added
271	N-102.3.1	Subparagraphs (b)(3)(-c), (-d), and (-e) added
275	Figure N-102.3.1-1	Added
289	N-127.7.2	Subparagraph (b) revised
290	N-127.7.3	Subparagraph (b) revised
295	Mandatory Appendix O	Added
298	Mandatory Appendix P	Added
304	II-2.2.1	(1) Subparagraphs (a)(3)(-a), (a)(3)(-d), (a)(3)(-e), and (b)(4)(-a) revised (2) Footnote 2 revised
308	Figure II-2.2.1-2	Name of y-axis revised
311	II-3.4	Second paragraph deleted
317	II-7.1.2	Revised
318	Figure II-7-1	Sizes for valve discharge elbow and valve vent pipe revised
320	II-7.1.3	In second equation, 103 psig corrected by errata to read 103 psia
321	II-7.1.7	Revised
322	II-7.1.8	Revised
322	II-7.1.10	Revised
330	V-6.2.2	Revised
340	Nonmandatory Appendix VI	Deleted
346	VII-3.3.3	Paragraph VII-3.3.4 redesignated as VII-3.3.3
355	Table VIII-2	A202 deleted

Figures and Tables Redesignated in ASME B31.1–2018

Figure Designators		Table Designators	
ASME B31.1-2016	ASME B31.1-2018	ASME B31.1-2016	ASME B31.1-2018
100.1.2(A.1)	100.1.2-1	102.4.3	102.4.3-1
100.1.2(A.2)	100.1.2-2	102.4.5	102.4.5-1
100.1.2(B.1)	100.1.2-3	102.4.6(B.1.1)	102.4.6-1
100.1.2(B.2)	100.1.2-4	102.4.6(B.2.2)	102.4.6-2
100.1.2(B.3)	100.1.2-5	102.4.7	102.4.7-1
100.1.2(C)	100.1.2-6	104.1.2(A)	104.1.2-1
102.4.5	102.4.5-1	112	112-1
104.3.1(D)	104.3.1-1	114.2.1	114.2.1-1
104.3.1(G)	104.3.1-2	121.5	121.5-1
104.5.3	104.5.3-1	121.7.2(A)	121.7.2-1
104.8.4	104.8.4-1	122.2	122.2-1
122.1.7(C)	122.1.7-1	122.8.2(B)	122.8.2-1
122.4	122.4-1	126.1	126.1-1
127.3	127.3-1	127.4.2	127.4.2-1
127.4.2	127.4.2-1	129.3.1	129.3.1-1
127.4.4(A)	127.4.4-1	129.3.3.1	129.3.3.1-1
127.4.4(B)	127.4.4-2	129.3.4.1	129.3.4.1-1
127.4.4(C)	127.4.4-3	131.4.1	131.4.1-1
127.4.8(A)	127.4.8-1	132	132.1.1-1
127.4.8(B)	127.4.8-2	132.1	132.1.1-2
127.4.8(C)	127.4.8-3	132.1.3	132.1.3-1
127.4.8(D)	127.4.8-4	132.2	132.2-1
127.4.8(E)	127.4.8-5	136.4	136.4.1-1
127.4.8(F)	127.4.8-6	136.4.1	136.4.1-2
127.4.8(G)	127.4.8-7	N-102.2.1(A)-1	N-102.2.1-1
135.5.3	135.5.3-1	N-102.2.1(A)-2	N-102.2.1-2
Chart D-1	D-2	N-102.2.1(A)-3	N-102.2.1-3
Chart D-2	D-3	N-119.6.1	N-119.6.1-1
N-127.7.1(B)	N-127.7.1-1	N-119.6.2	N-119.6.2-1
N-127.7.2(B)	N-127.7.2-1	N-126.1	N-126.1-1
N-127.7.3(B)	N-127.7.3-1	N-136.4.1(B)	N-136.4.1-1
N-127.8.1(B)	N-127.8.1-1	IV-5.2	IV-5.2-1
II-1.2(A)	II-1.2-2	VII-3.2.3	VII-3.2.3-1
II-1.2(B)	II-1.2-1	VII-6.3	VII-6.3-1
II-2-1	II-2.2.1-1	...	...
Chart II-1	II-2.2.1-2	...	...
II-2-2	II-2.2.1-3	...	...
II-3-1	II-3.5.1.3-1	...	...

Figure Designators		Table Designators	
ASME B31.1-2016	ASME B31.1-2018	ASME B31.1-2016	ASME B31.1-2018
II-3-2	II-3.5.1.3-2	...	...
II-7-3	II-7.1.9-1	...	...
Form V-7.5(A)	Form V-7.5-1	...	...
Form V-7.5(B)	Form V-7.5-2	...	...
Form V-7.5(C)	Form V-7.5-3
V-12.1.2	V-12.1.2-1
VII-5	VII-5-1
VII-6.4.4	VII-6.4.4-1
VII-6.6	VII-6.6-1

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Chapter I

Scope and Definitions

100 GENERAL

This Power Piping Code is one of several Sections of The American Society of Mechanical Engineers Code for Pressure Piping, B31. This Section is published as a separate document for convenience.

Standards and specifications specifically incorporated by reference into this Code are shown in [Table 126.1-1](#). It is not considered practical to refer to a dated edition of each of the standards and specifications in this Code. Instead, the dated edition references are included in an Addenda and will be revised yearly.

100.1 Scope

Rules for this Code Section have been developed considering the needs for applications that include piping typically found in electric power generating stations, in industrial and institutional plants, geothermal heating systems, and central and district heating and cooling systems.

- (18) **100.1.1** This Code prescribes requirements for the design, materials, fabrication, erection, test, inspection, operation, and maintenance of piping systems. Where service requirements necessitate measures beyond those required by this Code, such measures shall be specified by the engineering design.

Piping as used in this Code includes pipe, flanges, bolting, gaskets, valves, pressure-relieving valves/devices, fittings, and the pressure-containing portions of other piping components, whether manufactured in accordance with standards listed in [Table 126.1-1](#) or specially designed. It also includes hangers and supports and other equipment items necessary to prevent over-stressing the pressure-containing components.

Rules governing piping for miscellaneous appurtenances, such as water columns, remote water level indicators, pressure gages, and gage glasses, are included within the scope of this Code, but the requirements for boiler appurtenances shall be in accordance with ASME Boiler and Pressure Vessel Code (BPVC), Section I, PG-60.

The users of this Code are advised that in some areas legislation may establish governmental jurisdiction over the subject matter covered by this Code. However, any such legal requirement shall not relieve the owner of

his/her inspection responsibilities specified in [para. 136.1](#).

100.1.2 Power piping systems as covered by this Code (18) apply to all piping and their component parts except as excluded in [para. 100.1.3](#). They include but are not limited to steam, water, oil, gas, and air services.

(a) This Code covers boiler external piping as defined below for power boilers and high-temperature, high-pressure water boilers in which steam or vapor is generated at a pressure of more than 15 psig [100 kPa (gage)]; and high temperature water is generated at pressures exceeding 160 psig [1 103 kPa (gage)] and/or temperatures exceeding 250°F (120°C).

Boiler external piping shall be considered as piping that begins where the boiler proper terminates at

- (1) the first circumferential joint for welding end connections; or
- (2) the face of the first flange in bolted flanged connections; or
- (3) the first threaded joint in that type of connection, and that extends up to and including the valve or valves required by [para. 122.1](#).

The terminal points themselves are considered part of the boiler external piping. The terminal points and piping external to power boilers are illustrated by [Figures 100.1.2-1, 100.1.2-2, 100.1.2-3, 100.1.2-4, 100.1.2-5, 100.1.2-6, and 100.1.2-7](#).

Piping between the terminal points and the valve or valves required by [para. 122.1](#) shall be provided with Data Reports, inspection, and stamping as required by ASME BPVC, Section I. All welding and brazing of this piping shall be performed by manufacturers or contractors authorized to use the ASME Certification Mark and appropriate Designators shown in ASME CA-1, Conformity Assessment Requirements. The installation of boiler external piping by mechanical means may be performed by an organization not holding an ASME Certification Mark. However, the holder of a valid ASME Certification Mark, Certificate of Authorization, with an "S," "A," or "PP" Designator shall be responsible for the documentation and hydrostatic test, regardless of the method of assembly. The quality control system requirements of ASME BPVC, Section I; ASME CA-1; and ASME QAI-1, Qualifications for Authorized Inspectors shall apply.