ASME B31T-2021
(Revision of ASME B31T-2018)

Standard Toughness Requirements for Piping

ASME Code for Pressure Piping, B31

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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The American Society of Mechanical Engineers
Two Park Avenue • New York, NY • 10016 USA

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The next edition of this Standard is scheduled for publication in 2024.

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The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

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FOREWORD

In 2000, the ASME B31 Code for Pressure Piping, Materials Technical Committee (MTC) determined that there was a need to develop a standard set of toughness requirements for piping components that can be adopted by reference by various codes, standards, and specifications. At the time, the requirements of the ASME B31 Code books varied, with some having no requirements at all.

This Standard is intended to provide requirements for evaluating the suitability of materials used in piping systems for piping that may be subject to brittle failure due to low-temperature service conditions.

Under direction of ASME Standards and Certification, both SI and U.S. Customary units are provided. The 2010 edition of this Standard was approved by the American National Standards Institute (ANSI) on April 20, 2010.

The 2015 edition of this Standard was approved by ANSI on October 21, 2015.

The 2018 edition of this Standard was approved by ANSI on December 6, 2018.

The 2021 edition of this Standard was approved by ANSI on July 15, 2021.

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Code for Pressure Piping

(The following is the roster of the Committee at the time of the approval of this Standard.)

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General. ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions or a case, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B31 Standards Committee
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990
http://go.asme.org/Inquiry

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued to provide alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by the existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the Standard and the paragraph, figure, or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Standard to which the proposed Case applies.

Interpretations. Upon request, the B31 Standards Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the B31 Standards Committee.

Requests for interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at http://go.asme.org/InterpretationRequest. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt.

If the Inquirer is unable to use the online form, he/she may mail the request to the Secretary of the B31 Standards Committee at the above address. The request for an interpretation should be clear and unambiguous. It is further recommended that the Inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry in one or two words.
Edition:	Cite the applicable edition of the Standard for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. Please provide a condensed and precise question, composed in such a way that a “yes” or “no” reply is acceptable.
Proposed Reply(ies):	Provide a proposed reply(ies) in the form of “Yes” or “No,” with explanation as needed. If entering replies to more than one question, please number the questions and replies.
Background Information:	Provide the Committee with any background information that will assist the Committee in understanding the inquiry. The Inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in the format described above may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

Moreover, ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Standard requirements. If, based on the inquiry information submitted, it is the opinion of the Committee that the Inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Attending Committee Meetings. The B31 Standards Committee regularly holds meetings and/or telephone conferences that are open to the public. Persons wishing to attend any meeting and/or telephone conference should contact the Secretary of the B31 Standards Committee.

(21)

INTRODUCTION

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

Rules for each Section reflect the kinds of piping installations considered during its development, as follows:

B31.1 Power Piping: piping typically found in electric-generating stations, industrial and institutional plants, geothermal and solar power applications, and central and district heating and cooling systems

B31.3 Process Piping: piping typically found in petroleum refineries; onshore and offshore petroleum and natural gas production facilities; chemical, pharmaceutical, textile, paper, ore-processing, semiconductor, and cryogenic plants; food- and beverage-processing facilities; and related processing plants and terminals

B31.4 Pipeline Transportation Systems for Liquids and Slurries: piping that transports products that are predominately liquid between plants and terminals, and within terminals and pumping, regulating, and metering stations

B31.5 Refrigeration Piping and Heat Transfer Components: piping for refrigerants and secondary coolants

B31.8 Gas Transportation and Distribution Piping Systems: piping that transports 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 multiunit residences that do not require the range of sizes, pressures, and temperatures covered by ASME B31.1

B31.12 Hydrogen Piping and Pipelines: piping in gaseous and liquid hydrogen service and pipelines for gaseous hydrogen service

The following Codes and Standards provide guidance for a specific task found in one or more ASME B31 Section publications:

B31E Seismic Design and Retrofit of Above-Ground Piping Systems: establishes a method for the seismic design of above-ground metallic piping systems in the scope of the ASME B31 Code for Pressure Piping

B31G Remaining Strength of Corroded Pipelines: provides a simplified procedure to determine the effect of wall loss due to corrosion or corrosion-like defects on the pressure integrity in pipeline systems

B31J Stress Intensification Factors (*i*-Factors), Flexibility Factors (*k*-Factors), and Their Determination for Metallic Piping Components: provides a standardized method to develop the stress intensification factors (*i*-factors), flexibility factors (*k*-factors), and sustained stress factors used in ASME B31 piping analysis

B31P Standard Heat Treatments for Fabrication Processes: provides requirements for heat treatment of piping assemblies that meet the requirements of ASME B31 Code Sections

B31Q Pipeline Personnel Qualification: establishes the requirements for developing and implementing an effective Pipeline Personnel Qualification Program

B31T Standard Toughness Requirements for Piping: provides requirements for evaluating the suitability of materials used in piping systems for piping that may be subject to brittle failure due to low-temperature service conditions

This is ASME B31T, Standard Toughness Requirements for Piping. Hereafter, in this Introduction and in the text of ASME B31T, where the word “Standard” is used without specific identification, it means ASME B31T.

This Standard provides requirements for evaluating the suitability of materials used in piping systems for piping that may be subject to brittle failure due to low-temperature service conditions. While low-temperature service is

usually considered to be below ambient temperature, brittle failure can occur at temperatures above ambient temperature for certain combinations of materials, thicknesses, and stress levels. The definition of "low-temperature service" as used in this Standard, therefore, varies widely across the many applications for which piping systems are used. For a building service air line, low temperature may be 0°C (32°F), whereas for a cryogenic piping system, it could easily be −185°C (−300°F). However, the principles used to evaluate the suitability of a piping system as related to service temperature by evaluating the toughness of the material can be applied across a wide temperature range, and this Standard has been established to provide uniform guidance in this area.

Suitability of piping systems for low-temperature service is a function of several variables, including material properties, design loadings, and fabrication procedures. The three primary factors that generally control the susceptibility for brittle fracture are material toughness, crack size, and tensile stress level. There are a wide variety of services where low-temperature suitability need not even be considered; however, a screening criterion is necessary to determine this.

One objective of this Standard is to provide a simple approach to evaluate whether additional consideration is necessary to evaluate suitability for low-temperature service. This is done by establishing a low-temperature service limit for various materials. Services at or warmer than this limit are not considered low temperature, and additional considerations relative to suitability are not required.

For services colder than this limit, various requirements are provided that, when met, qualify the material for low-temperature services. These requirements include impact testing, qualification of welding and other fabrication procedures, and limiting the design loadings.

The low-temperature service limit established herein is based on a reasonable degree of assurance that at this temperature, the material will have a ductile failure mode. The actual ductile-to-brittle transition temperature for a given material specification will vary based on actual heat chemistry of the material and subsequent processing. For critical applications, the design engineer can select materials with a lower low-temperature service limit or require impact testing. On less-critical applications, material with a higher low-temperature service limit may be acceptable. The final selection is left to the code, standard, or specification referencing this Standard and the design engineer (when permitted by the code, standard, or specification referencing this Standard).

To keep the number of sets of requirements to a minimum, material groupings have been established, and a unique set of requirements have been provided for each group. These groups are assigned "T-numbers" for easy reference. Although most materials used in piping systems are listed, some are not, and these unlisted materials are not addressed in this Standard. Where permitted by the code, standard, or specification referencing this Standard, these requirements may be used for unlisted materials. The code, standard, or specification referencing this Standard may establish the correct T-number group for the material or may invoke the testing and other requirements of this Standard using the worst-case assumption that the design minimum temperature is colder than the temperatures that would allow exemption from any of the requirements of this Standard. The guidelines for establishing the correct T-number group are provided in Nonmandatory Appendix B.

Either International System (SI, also known as metric) or U.S. Customary (USC) units may be used with this edition. Local customary units may also be used to demonstrate compliance with this Standard. One system of units should be used consistently for requirements applying to a specific installation. It is the responsibility of the organization performing calculations to ensure that a consistent system of units is used.

The ASME B31 Committee is organized and operates under procedures of ASME that have been accredited by the American National Standards Institute. The Committee is continuing and keeps all Code Sections and Standards current with new developments in methods, materials, construction, and industrial practice.

This Standard may be invoked in whole or in part by various codes, standards, or specifications and is only mandatory when so invoked. The applicable edition of this Standard shall be as specified by the code, standard, or specification referencing this Standard. It is intended that this edition of the ASME B31T Standard not be retroactive. Users of this Standard are cautioned against making use of Standard revisions without assurance that they are acceptable to the proper authorities in the jurisdiction where the material is to be installed.

ASME B31T-2021
SUMMARY OF CHANGES

Following approval by the ASME B31 Committee and ASME, and after public review, ASME B31T-2021 was approved by the American National Standards Institute on July 15, 2021.

ASME B31T-2021 has replaced the word "Code" with "Standard" in all references to itself. In addition, this edition includes the following changes identified by a margin note, **(21)**.

Page	*Location*	*Change*
viii	Introduction	Added
1	1	Revised in its entirety
1	2	(1) Definition of *fully deoxidized steel* revised (2) Definition of *governing thickness* added
1	3.2	First sentence revised
2	3.3	Revised in its entirety
2	3.4	Revised
2	3.5	Revised
3	3.7.1	First two paragraphs revised
3	3.7.2.2	Second paragraph revised
3	3.7.2.3	First two paragraphs revised
5	3.7.4.2	Last paragraph revised
6	3.7.4.3	Revised
6	4.1	Revised
6	4.2	Second paragraph and subpara. (a) revised
8	5	Added
12	Table 3.1-1	Second column head revised
28	Table 3.2-1	(1) First A134 row and A167, A202, A226, A325, and A570 rows deleted (2) Last A134 row, A283 row, and first two A320 rows revised (3) Penultimate A193 row, last A453 row, A1011 row, and General Note (a) added
36	Table 4.5.1-1	First column revised to show SI units as primary
37	Mandatory Appendix I	Title and first paragraph revised
38	Figure I-1	Title, axis and curve labels, and curve CS B revised
39	Figure I-1M	Title and axis and curve labels revised
40	Table I-1	Column heads revised
46	Table III-1	(1) CS –20, A226 and A325; CS A, A570; CS B, first A134; LA –20, A202; SS –325, A167; and SS –20, A167 rows deleted (2) CS –20, F3125; CS A, A1011; SS –425, A193; SS –325, A453; and General Note (a) added (3) CS A, last A134 and A283; SS -425, A320; and SS -325, A193 and A320 rows revised

Page	*Location*	*Change*
54	Figure A-1	First two boxes under “Low-Temperature Service Requirements Evaluation” revised
55	Nonmandatory Appendix B	“T-number(s)” revised to “T-number group(s)” throughout

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STANDARD TOUGHNESS REQUIREMENTS FOR PIPING

(21) ## 1 GENERAL

1.1 Scope

This Standard provides requirements for evaluating the suitability of materials used in piping systems for piping that may be subject to brittle failure due to low-temperature service conditions.

1.2 Units of Measure

This Standard states values in both International System (SI, also known as metric) and U.S. Customary (USC) units. Within the text, the USC units are shown in parentheses or in separate tables. The values stated in each system are not exact equivalents; therefore, each system of units should be used independently of the other.

When separate equations are provided for SI and USC units, those equations shall be executed using variables in the units associated with the specific equation. The result obtained from execution of these equations may be converted to other units.

When necessary to convert from one system of units to another, conversion should be made by rounding the values to the number of significant digits of implied precision in the starting value but not less than four significant digits for use in calculations.

(21) ## 2 GLOSSARY

CVN: the abbreviation for Charpy V-notch.

design minimum temperature: the lowest component temperature expected in service.

fully deoxidized steel: steel that has been deoxidized, either by the addition of strong deoxidizing agents or by vacuum treatment, to reduce the oxygen content to such a level that no reaction occurs between the carbon and oxygen during solidification. Also known as killed steel. Steels that are not fully deoxidized include rimmed, semi-killed, and capped steels. Limitations on the use of steels that are not fully deoxidized may be imposed by the code, standard, or specification referencing this Standard.

governing thickness: the thickness used in determining the low-temperature service limit of T-number groups CS A, CS B, CS C, and CS D in Table 3.1-1. Unless defined differently in the code, standard, or specification referencing this Standard, this thickness is the nominal thickness of the component or, for blind flanges and line blanks, $^1/_4$ of the total thickness, where the total thickness is the thickness of the blind flange or line blank, including the thickness of the facing(s), if applicable.

lower critical temperature: the temperature at which the first phase change occurs when heating a metal.

low-temperature service limit: the design minimum temperature at which additional requirements for low-temperature service do not apply.

NDT temperature: the nil ductility transition temperature.

stress ratio: the ratio of the design stress to an allowable stress. (See para. 3.6.2.)

T-number: a number assigned to a group of similar materials with similar low-temperature requirements. The number consists of the material type and a temperature characteristic, and possibly a suffix.

3 LOW-TEMPERATURE RANGES AND REQUIREMENTS

3.1 Low-Temperature Service Requirements

Low-temperature service requirements are contained in Table 3.1-1. These requirements are established for T-number groups of materials with similar requirements. In addition to T-number group, in some cases, requirements are dependent on thickness and/or other characteristics as listed in Table 3.1-1.

3.2 Material Groupings (Column 1 of Table 3.1-1) (21)

Listed materials are assigned T-number groups in Table 3.2-1. (In addition, a table sorted by material type and T-number group that lists all materials in each T-number group is provided in Mandatory Appendix III.) In determining the applicable T-number group for a material from Table 3.2-1, consideration shall be given to the material specification, grade, and any other variables as established in the notes. The table separates the materials into types (carbon steels, low-alloy steels, etc.), and the group number is representative of the low-temperature service limit for the material; however, the low-temperature service limit may vary based on the design and fabrication requirements. Low-temperature service limits shall be determined from Table 3.1-1. An "(A)" in the T-number group [e.g., CS −20(A)] indicates that materials of that group may not be used