

ASME CODES AND STANDARDS

WRITING GUIDE AND EDITORIAL STYLE GUIDE



**The American Society of
Mechanical Engineers**

ASME CODES AND STANDARDS

WRITING GUIDE AND EDITORIAL STYLE GUIDE



**The American Society of
Mechanical Engineers**

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FOREWORD

For more than 125 years, the American Society of Mechanical Engineers (ASME) has been developing standards as part of its mission to advance engineering for the benefit of humanity. Today, ASME's portfolio of standards spans an ever-evolving range of topics, from, literally, nuts and bolts to elevators, pressure technology, nuclear components, and many others. All ASME standards are living documents, consistently reviewed and updated to ensure they capture technological advancements, reflect current industry practice, and promote public safety.

The *ASME Codes and Standards Writing Guide and Editorial Style Guide* is a resource for everyone involved in writing ASME standards. The guide explains basic principles of clear writing and establishes the required style for all aspects of ASME standards. Consistent application of the rules in the guide will help ensure ASME publishes clearly written, technically precise standards that make the world a safer place.

PART I

WRITING GUIDE (WG)

SUBPART WG1

INTRODUCTION TO WRITING ASME CODES AND STANDARDS

WG1-1 WHAT IS “STYLE” AND WHY DOES IT MATTER?

The ASME Codes and Standards Writing Guide and Editorial Style Guide documents the “house style” that shapes ASME’s codes and standards. Style includes the manner and order in which information is presented; the rules regarding punctuation, abbreviations, and other text elements; and other editorial concerns. ASME style is essential to the standards-development process because it ensures the consistent presentation of information from page to page and from standard to standard. Consistency prevents ambiguity that could compromise the user’s understanding of the material. By applying the rules in this guide, ASME committee members, technical staff, and editors help maintain the informational integrity of ASME’s publications.

WG1-2 CODES AND STANDARDS — DEFINITIONS AND REQUIREMENTS

WG1-2.1 Definition of a Standard

A standard consists of technical definitions and guidelines that function as instructions for designers, manufacturers, operators, and users of equipment. Standards can run from a few pages to a few hundred pages and are written by professionals who serve on ASME committees. Standards are considered voluntary because they are guidelines and not enforceable by law. ASME publishes standards, accredits users of standards to ensure that they are capable of manufacturing products that meet those standards, and provides stamps that accredited manufacturers may place on their products to indicate conformance to a standard.

WG1-2.2 Definition of a Code

A code is a standard that has been adopted by one or more governmental bodies and is enforceable by law.

WG1-2.3 Requirements for Codes and Standards

To be considered a valid ASME code or standard, a document

(a) should be suitable for repetitive use. A major requirement of a code or standard is that it can be used time and again. If a set of requirements is so specia-

lized that it cannot and will not be applied repeatedly, it is not a code or standard.

(b) should be enforceable. A standard’s requirements should be worded so that a person auditing the use or application of the standard can identify the requirements that have or have not been met.

(c) should be definite. Requirements that are too general or contain vague applications instead of workable instructions are impractical and often useless. Requirements should be expressed as specific instructions and never as explanations.

(d) should be realistic. Requirements should not be arbitrary; rather, they should be based on factors that are necessary to achieve the purpose of the standard. Do not include requirements that are unrelated, excessive, or more restrictive than necessary. A standard that is too restrictive or detailed imposes a burden on both the administrator and the user. Increasing the severity or detail of a requirement does not automatically increase quality but will nearly always increase cost. Be ready to justify, in writing if necessary, every requirement of the standard and show the basis of each as a logical deduction from factual information about the item or practice in question.

(e) should be authoritative. Requirements should be technically correct and accurate and cover only those properties that are subject to control or are of legitimate use. Requirements should be consistent with current practices and capabilities in the industry, and be attainable for the user.

(f) should be complete. All areas open to question or interpretation (or misinterpretation) should be covered. If requirements are specified in terms of or by reference to another standard, all areas of the referenced standard that are open to question or misinterpretation should also be covered.

(g) should be clear. Requirements should be written in easily understood language that is not ambiguous. Language should be precise and concise. Avoid common pitfalls such as run-on sentences, wordiness, redundancy, and complex sentence structures.

(h) should be consistent. Requirements should not be contradictory or incompatible with one another. Similarly, the requirements of related and dependent standards should also be consistent with each other. Also, the requirements should be compatible with the requirements

of the documents referenced in the standard, and the standard should reflect national or international standards whenever possible. Special (i.e., nonstandard) sizes, shapes, or tests require special attention and extra time on the part of the user and therefore increase cost; they also inhibit maintenance and repair.

(i) should not cover too broad a scope. When too much is covered by one standard, its requirements become confusing and the standard becomes less effective. Users may be left wondering which parts of the standard apply to their work. When the standard applies to a variety of users with different requirements, it is often more desirable to provide separate standards.

WG1-3 PREPARING TO WRITE AN ASME CODE OR STANDARD

WG1-3.1 Purpose and Audience

The first step in writing a code or standard is to define the purpose of the document. What is the document intended to convey? What action does the user need to take in response to the document? What information and emphasis should the document communicate to enable the user to take the recommended action? The answers to these questions shape the scope of the document. The scope should clearly define the information the code or standard covers.

As you formulate the scope of the code or standard, consider also the intended user of the document. Who is going to reference the code or standard? Who will take some action because of it? What background or knowledge does the user most likely have? How can you arrange the code or standard so that the user will be sure to understand its meaning? Also bear in mind that ASME codes and standards serve an international audience. Clear, concise writing and proper grammar help ensure that a code or standard communicates clearly to all the intended users.

WG1-3.2 Outline

Once you have defined the purpose of and audience for the code or standard, create a detailed outline of the expected content. Divide the outline into primary and subordinate topics; you can easily omit unnecessary topics and subtopics later. Be sure that the outline reflects the emphasis you want and that the topics and subtopics bear the proper relationship of equality and subordination to one another. See [Subpart WG2](#) for guidance on required elements of an ASME code or standard.

Organize your outline using numerical or alphanumeric designators and titles or captions. If you cannot readily apply a designator and title to a paragraph, table, figure, or appendix, some incongruity probably exists in the outline, and you should consider rearranging the material. Designation is the most crucial aspect of the

document's organization. The document's overall structure requires the same level of thought and consideration as the technical content. Codes and standards should follow similar patterns of arrangement and designation. At the very least, related codes and standards, particularly those within a series, should follow established parallel structures. See the following paragraphs for designation style rules:

(a) for paragraphs and subparagraphs, [SG2-2.1](#) and [SG2-2.2](#)

(b) for appendices, [SG2-3](#)

(c) for tables, [SG4-2](#)

(d) for figures, [SG5-3](#)

WG1-3.3 Recurring Sections

(a) *Scope*. As mentioned in [WG1-3.1](#), the scope is typically the first designated paragraph of the book. The scope is usually titled "SCOPE," is no more than a few paragraphs long, and may include a breakdown [i.e., a labeled list of subparagraphs or items (see [SG2-2.2](#))]. The scope is a careful overall description of the code's or standard's purpose and content. The scope should define the parameters of a document so that users can immediately discern whether the standard or code addresses their particular topics of concern. See [Example WG1.1](#).

(b) *Definitions*. The scope is typically followed by a definitions section, usually titled "DEFINITIONS." You may choose instead to locate the definitions section after the references [see (c)] or in a mandatory appendix. Whichever your preference for location, the definitions section defines the terms, acronyms, abbreviations, symbols, and phrases relevant to the code or standard. Even if writing a multichapter code or standard, create a single, comprehensive, alphabetized list of definitions. A single alphabetized definitions list, uninterrupted by subheadings, is more user friendly and more easily maintained than multiple, subcategorized lists spread throughout a standard. See [SG2-2.4](#) for style rules for definitions sections.

(c) *References*. A references section, titled "REFERENCES," typically follows the definitions section. You may choose instead to list references before the definitions section or in a mandatory appendix. Whichever your preference for location of the reference list, the list must include *all* references cited in the text of the code or standard. Even if writing a multichapter code or standard, create a single reference list, not individual reference lists for each chapter. As for definitions lists, a single reference list is more user friendly and more easily maintained than multiple lists.

The cited references should be documents that the user of the code or standard can readily obtain from the publisher or other source. Do not cite technical papers, out-of-print books, in-house reports, or other documents that will be inaccessible to the user. If citing an obscure reference, you may seek permission from the publisher to

extract the relevant portion (e.g., a figure) and reproduce it in the code or standard. However, be aware that permissions can be time-consuming and costly for ASME to obtain. See [WG3-6](#) for policies on the use of copyrighted material. See [SG2-2.10](#) for style rules that apply to the use of copyrighted material.

Once issued, a standard will be the authority and should not lean on other documents for credibility. References are a means of reducing the bulk or detail of the standard. For example, a standard may cite an ASTM publication for a test method or acceptable material or procedure. However, a standard should not cite a paper by an expert in the field simply to lend weight to a requirement.

When compiling the reference list, decide whether to cite the specific edition year for referenced codes and standards. Keep in mind that a cited code or standard may change significantly from one edition to the next, and these changes may in turn affect provisions for safety or interchangeability in the standard you are writing. If a cited code or standard is likely to vary from edition to edition, cite the edition year in the reference list.

See [SG2-2.9](#) for style rules for references and [Example WG1.2](#) for a reference list.

NOTE: The committee is responsible for submitting a complete, accurate reference list with each manuscript. The C&S Publishing editor copyedits the reference list for proper ASME style but is not responsible for fact-checking the publication details of the references.

WG1-3.4 Principles of Clear Writing

The style of writing contributes to the effectiveness and usefulness of a code or standard. Concise, precise, grammatically correct sentences ensure that all users understand the meaning in exactly the same way. The following general principles provide a foundation for clearly written codes and standards:

(a) *Limit sentence length.* Express only one requirement, recommendation, or other point of information per sentence. Use several short sentences (i.e., of about 20 words) rather than one long, complex sentence to communicate a complicated idea.

(b) *Write in active voice.* Active voice makes the “doer” of the action the subject of the sentence. Active voice almost always communicates more precisely and concisely than passive voice. Consider the following sentences:

Active Voice: The Manufacturer shall complete a Manufacturer’s Data Report for each pressure vessel.

Passive Voice: The Manufacturer’s Data Report shall be completed by the Manufacturer for each pressure vessel.

The active voice example communicates directly who or what is responsible for the action: the Manufacturer completes the report. The active voice example also properly places the prepositional phrase “for each pressure vessel” next to the noun it modifies, “Report.” In contrast,

the passive voice example lacks authority: the Manufacturer isn’t directly doing the action. In addition, use of passive voice produces a misplaced modifier: the prepositional phrase “for each pressure vessel” seems to be modifying “Manufacturer” rather than “Report.” Finally, the passive voice example is two words longer than the active voice example.

(c) *Use simple words.* Codes and standards require the use of technical terms (e.g., “permeability,” “accelerometer,” “hydropneumatic”) that are part of the mechanical engineering vocabulary. However, joining the needed technical terms with needlessly grandiose nontechnical words risks obscuring meaning and exhausting the user. Therefore, choose simple, familiar words for nontechnical expressions. For example, substitute “use” for “utilize” or “employ”; “show” for “demonstrate”; and “start” or “begin” for “initiate.”

(d) *Write precisely and concisely.* Choose and order words carefully to ensure they express the intended meaning. Eliminate redundancy and wordiness. The following table provides examples of commonly used phrases and their one-word alternatives:

Phrase	Alternative
aluminum metal	aluminum
for a duration of	for
fuse together	fuse
give approval	approve
in order to, for the purpose of	to
in the course of	during
in the event that	if
is provided with	has
large number, great deal of	<i>specify a quantity to eliminate ambiguity</i>
make a decision	decide
period of time	period
physical size	size
take a measurement	measure
through the medium of	by
visible to the eye	visible

(e) *Review your draft.* Take time during the writing process to assess what you’ve written. Read sentences aloud and listen to the flow of words. Is the language precise? Is the meaning clear? Ask a colleague to review the writing for clarity and sense. Use a Flesch-Kincaid calculator¹ to assess the readability of your work. If the results show a reading level greater than grade 12, review your sentences for length, grammar, and word choice. Revise by applying the principles in (a) through (d).

¹ Microsoft Word’s Proofing function has a “Show readability statistics” option that provides a Flesch-Kincaid score. Alternatively, free Flesch-Kincaid calculators are available online.

WG1-3.5 Editorial Developmental Review

ASME Codes and Standards (C&S) Publishing recommends that committees writing new standards or substantially revising existing standards submit their drafts for developmental review. This review is designed to identify

and resolve editorial issues early in a document's development, thereby preventing delays later in the production process. For details, see "Guide to Development Review of New or Substantially Changed Standards" in C&S Connect.²

²To access the Guide to Developmental Review of New or Substantially Changed Standards, go to <https://go.asme.org/standards-procedures> and select "Guides" from the "Sub-Folders" drop-down menu.

SUBPART WG2

ELEMENTS OF AN ASME CODE OR STANDARD

WG2-1 ORGANIZATION OF A CODE OR STANDARD

ASME codes and standards are organized into the elements below. Not all elements apply in all codes and standards. See [WG2-2](#) for a detailed description of each element.

(a) Front Matter

- (1) title page
- (2) copyright page
- (3) table of contents
- (4) foreword
- (5) committee roster
- (6) committee correspondence page
- (7) summary of changes (SOC)
- (8) list of changes in record number order (LOC)

(ASME B16 standards only)

(b) Main Text

- (1) chapters or sections and subsections
- (2) paragraphs, subparagraphs, and breakdowns
- (3) in-text notes
- (4) footnotes
- (5) tables
- (6) figures
- (7) equations

(c) Back Matter

- (1) mandatory appendices
- (2) nonmandatory appendices
- (3) endnotes
- (4) index

NOTE: Cases and interpretations, formerly included in the back matter, are no longer published in the editions. See [WG2-3](#) and [WG3-4](#) for information on cases and interpretations, respectively.

WG2-2 DESCRIPTION OF ELEMENTS

WG2-2.1 Front Matter

WG2-2.1.1 Title Page. The title page contains the designation, edition year, revision and reaffirmation information, title of the code or standard, book type [e.g., “An American National Standard”], and the ASME cloverleaf banner with address. The edition year is the year in which the American National Standards Institute (ANSI) grants approval of the code or standard. For documents not requiring ANSI approval (e.g., errata, technical reports, draft standards), the publication year is also the

edition year. C&S Publishing generates the title page for publication. See [Example WG2.1](#). See Codes and Standards Policies¹ CSP-9(a) and CSP-9(b) for requirements for title pages of drafts.

WG2-2.1.2 Copyright Page. See [WG3-2](#) for details on the copyright page (see also [Examples WG3.1](#) and [WG3.2](#)).

WG2-2.1.3 Table of Contents. C&S Publishing generates the table of contents, which includes the following elements:

- (a)* front matter (e.g., foreword, committee roster, committee correspondence page, SOC)
- (b)* chapters, sections, and subsections, if any, and first-level paragraph headings
- (c)* figures
- (d)* tables
- (e)* forms
- (f)* mandatory appendices
- (g)* nonmandatory appendices
- (h)* endnotes
- (i)* index (if applicable)

See [Examples WG2.2](#) and [WG2.3](#).

WG2-2.1.4 Foreword. The foreword traces the history of a code or standard through its acceptance as an American National Standard. Technical information does not appear in the foreword. The committee or the ASME staff secretary writes and updates the foreword, which includes the following information:

- (a)* a history of the standard
- (b)* a description of the standard’s purpose
- (c)* for a revision, a description of the principal changes between the current and previous edition
- (d)* the ANSI approval date

See [Example WG2.4](#).

WG2-2.1.5 Committee Roster. The committee roster lists the members of the committee at the time of the code’s or standard’s approval. The committee roster may include one or more subcommittees or other subgroups. The ASME staff secretary submits the committee roster to C&S Publishing along with the manuscript. See [SG2-1.3](#) for roster style rules and examples.

¹ To access Codes and Standards Policies, go to <https://go.asme.org/standards-procedures> and select “Policies” from the “Sub-Folders” drop-down menu.

WG2-2.1.6 Committee Correspondence. The committee correspondence page provides information on contacting the committee, proposing revisions or cases, publishing errata, and submitting requests for interpretation. C&S Publishing generates the committee correspondence page. See [Example WG2.5](#).

WG2-2.1.7 SOC. The SOC serves as a reference to the changes contained in the edition. The SOC comprises three columns: *Page*, *Location*, and *Change* or, if the code or standard includes an LOC, *Change (Record)*. The locations in the SOC correspond to margin designators placed in the text (see [SG2-2.7](#)). The change descriptions in the SOC briefly describe the changes at the identified locations. All Sections of the ASME Boiler and Pressure Vessel Code (BPVC) include an SOC. For other codes and standards, the committee determines whether to include an SOC. C&S Publishing generates the SOC. See [SG2-1.4](#) for SOC style rules and examples.

WG2-2.1.8 LOC. In ASME B16 standards only, an LOC follows the SOC page. The LOC comprises two columns: *Record Number* and *Change*. The ASME staff secretary extracts the change descriptions from C&S Connect, compiles the LOC, and submits the LOC to C&S Publishing along with the manuscript. See [SG2-1.5](#) for LOC style rules and examples.

WG2-2.2 Main Text

WG2-2.2.1 Chapters, Paragraphs, Subparagraphs, and Sub-Subparagraphs

(a) *Nonchapter Standards.* Most ASME codes and standards (e.g., A112, B18, B89, B107) divide the text into paragraphs identified by first-level headings. Each first-level paragraph may be divided further into subparagraphs and sub-subparagraphs identified by second-, third-, and fourth-level headings. See [SG2-2.1.1](#) for style rules for designating the headings of nonchapter standards.

(b) *Multichapter Standards.* Some ASME codes and standards [e.g., Performance Test Codes (PTCs)] divide the main text into Chapters or Sections designated with single digits, i.e., 1, 2, 3, etc. Each Chapter or Section is divided into paragraphs, subparagraphs, and sub-subparagraphs identified by headings in a manner similar to that described for nonchapter books. See [SG2-2.1.2](#) for style rule for designating the headings of multichapter standards.

WG2-2.2.2 Breakdowns. Breakdowns are alphanumerically labeled lists. Breakdowns may occur within a paragraph, subparagraph, or sub-subparagraph or immediately following a heading. See [SG2-2.2](#) for style rules for breakdowns.

WG2-2.2.3 In-Text Notes. In-text notes appear immediately after the paragraph or group of paragraphs to which the noted information applies. Unlike endnotes or footnotes, in-text notes are part of the code or standard. See [SG2-2.5.1](#) for style rules for in-text notes. See also [SG2-2.6](#) for style rules for exceptions, examples, warnings, and cautions.

WG2-2.2.4 Footnotes and Endnotes. Footnotes and endnotes are for citation, clarification, or illustration only. Footnotes and endnotes are not considered part of the standard. All BPVC Sections use endnotes except Mandatory Appendix IV of Section II, Parts A and B, which uses footnotes. For all other codes and standards, C&S Publishing determines whether to use footnotes or endnotes. See [SG2-2.5.2](#) and [SG2-2.5.3](#) for style rules for footnotes and endnotes, respectively.

WG2-2.2.5 Equations. See [Subpart SG3](#) for style rules for equations.

WG2-2.2.6 Tables. Tables are an efficient means for presenting interrelated or copious data (numerical, textual, or both). Tables fall into two broad categories: designated and in-text. Designated tables comprise a designator, title, and multiple columns and rows of data. Designated tables are designated based on the “parent paragraph,” i.e., the paragraph that introduces the data in or topic of the table. In-text tables have no designator or title, comprise only a few columns and rows of data, and are located within or immediately after the paragraph that introduces them. Both designated and in-text tables use boldface column headings to identify the data in the columns. Both types of tables may include general or referenced notes. Like in-text notes, table notes are considered part of the code or standard.

The C&S Publishing editor reviews each table during the manuscript-editing process to ensure proper format of the table and clear presentation of data. See [Subpart SG4](#) for style rules for tables.

WG2-2.2.7 Figures. Figures may appear in the main text or appendices to illustrate the information provided in text. The ASME staff secretary submits figure files with the manuscript. See the following documents in C&S Connect² for acceptable figure types and file formats:

(a) Guidelines for Presenting Proposed Revisions for Ballot and Submittal of Approved Revisions to C&S Publishing

(b) ASME Artwork Specification

See [Subpart SG5](#) for style rules for figures.

²To access the cited documents, go to <https://go.asme.org/standards-procedures> and select “Guides” from the “Sub-Folders” drop-down menu.

WG2-2.3 Back Matter

WG2-2.3.1 Mandatory Appendices. Mandatory appendices are part of the code or standard, providing supplementary requirements, recommendations, and information. Mandatory appendices follow the main text. See [SG2-3](#) for style rules for mandatory appendices.

WG2-2.3.2 Nonmandatory Appendices. Nonmandatory appendices are not a part of the code or standard. Nonmandatory appendices provide only clarification, illustrations, examples, and general information. Nonmandatory appendices follow mandatory appendices. See [SG2-3](#) for style rules for nonmandatory appendices.

WG2-2.3.3 Indices. C&S Publishing no longer implements indices in new codes and standards. Several existing ASME codes and standards (e.g., ASME A17.1, ASME BPE) maintain an index. The committee or ASME staff secretary updates the index during manuscript preparation.

WG2-3 CASES

A committee may issue a case to permit early implementation of a revision based on an urgent need, to provide alternative requirements, or to allow users to gain experience with alternative or potential requirements before incorporating the requirements into the code or standard. A case is effective for use when the public review process has been completed and the case is approved by the cognizant supervisory board. A committee may issue a new case, annul or revise an approved case, reinstate an annulled case, or correct a case by errata.

Approved cases for a non-BPVC code or standard are posted on the committee web page. Cases for BPVC Sections, i.e., Code cases, are published in two Code

Case books, “Boilers and Pressure Vessels” and “Nuclear Components,” with each BPVC edition. Each BPVC Code Case book is updated with seven supplements during the two-year BPVC cycle. Each BPVC Code Case book comprises the following elements:

- (a) title page
- (b) copyright page
- (c) SOC
- (d) numeric index
- (e) subject index
- (f) Index of Material Specifications Referred to in Cases
- (g) Charts for Vessels Under External Pressure (included in the “Boiler and Pressure Vessels” Code Case book only)
- (h) Applicability Index for Section XI Cases (included in the “Nuclear Components” Code Case book only)
- (i) Guideline for Cross-Referencing Section XI Cases (included in the “Nuclear Components” Code Case book only)
- (j) numerically ordered cases, each formatted as an inquiry and a reply

Information regarding proposing and issuing a case is included in the committee correspondence page (see [WG2-2.1.6](#)). See [SG2-4](#) for Code case style rules and examples.

WG2-4 ERRATA

An errata sheet lists errors discovered after a book has gone to press. C&S Publishing publishes errata sheets only for errors that, in the judgment of the relevant Standards and Engineering Services director, could pose a safety concern. ASME staff secretaries are responsible for posting other types of errata on the relevant committee web page. See [SG2-5](#) for style rules for errata sheets.

SUBPART WG3

SPECIAL POLICIES

WG3-1 GENERAL

Special policies affecting the writing of ASME codes and standards are summarized below and derived from the ASME Codes and Standards Policies (CSP),¹ adopted by the ASME Board of Governors, and ANSI Essential Requirements: Due Process Requirements for American National Standards.

Special policies affect the following:

- (a) copyright page (see [WG3-2](#))
- (b) effective dates (see [WG3-3](#))
- (c) interpretations (see [WG3-4](#))
- (d) rationale (see [WG3-5](#))
- (e) use of copyrighted material (see [WG3-6](#))
- (f) commercial equipment (see [WG3-7](#))
- (g) reference to patented items (see [WG3-8](#))
- (h) system of measurement (see [WG3-9](#))

WG3-2 COPYRIGHT PAGE

The copyright page provides the following information:

- (a) date of issuance and year of publication
 - (b) effective date, if applicable (see [WG3-3](#)), and expected date of next edition
 - (c) copyright statements required by CSP [see CSP-9(f) and CSP-33(b)(3)]
 - (d) an illustration of the ASME cloverleaf
 - (e) for the following codes and standards, an illustration of the ASME Single Certification Mark:
 - (1) the ASME BPVC and pressure technology standards ASME RTP-1 and ASME BPE
 - (2) conformity assessment standards ASME ANDE-1, ASME CA-1, ASME QAI, ASME QFO, and ASME QRO
- C&S Publishing generates the copyright page. See [Examples WG3.1](#) and [W3.2](#).

WG3-3 EFFECTIVE DATES

Unless otherwise established by the cognizant supervisory board, every safety code or standard shall have a statement included in its foreword or other introductory matter regarding the effective dates for use of an edition. See CSP-9(c)(2).

¹To access the ASME CSP, go to <https://go.asme.org/standards-procedures> and select “Policies” from the “Sub-Folders” drop-down menu.

WG3-4 INTERPRETATIONS

A committee issues interpretations of a code’s or standard’s requirements only in response to user requests. Interpretations are issued in real time in ASME’s Interpretations Database at <http://go.asme.org/Interpretations>.

See CSP-33 for requirements for interpretations.

Information regarding requests for and issuance of interpretations is included in the committee correspondence page. See [WG2-2.1.6](#) and [Example WG2.5](#).

WG3-5 RATIONALE

The rationale for the requirements of a consensus code or standard should never be included as part of the document. The fact that the code or standard was generated through consensus and public approval suffices as the rationale. However, if the committee finds it necessary, a rationale may be printed in the foreword or a nonmandatory appendix, provided the rationale is subject to the complete approval procedures, including public review. See CSP-9(g).

WG3-6 USE OF COPYRIGHTED MATERIAL

If in developing a code or standard a committee proposes to incorporate material from the copyrighted publication of another organization, the ASME staff secretary must obtain written permission from the publisher to republish or adapt the material. Material requiring permission includes but is not limited to text, tables, and figures from print products and electronic sources (e.g., the Internet, PDF-only publications). Contact the ASME manager of intellectual property rights for assistance in obtaining copyright permissions. See [SG2-2.10](#) for style rules for the use of copyrighted materials.

WG3-7 COMMERCIAL EQUIPMENT

References to commercial equipment should be generic and should not include trademarks or other proprietary designations. Where a sole source exists for essential equipment or materials, it is permissible to supply the name and address of the source in a footnote as long as the words “or the equivalent” are added to the reference. See CSP-59(b) and the commercial terms and conditions policy in ANSI Essential Requirements: Due Process

Requirements for American National Standards, section 3-2.

WG3-8 REFERENCE TO PATENTED ITEMS

The practice of developing a code or standard that calls for the use of a patented item should be avoided; however, such a code or standard is not prohibited. ASME should be consulted for guidelines if patented items are to be covered. See CSP-59(a) and patent policy in ANSI Essential Requirements: Due Process Requirements for American National Standards, section 3-1.

WG3-9 SYSTEM OF MEASUREMENT

Policy 9.1 of the ASME Board of Governors requires the following: “All units in works, papers, and periodicals published by ASME shall conform to SI. English units may be included. The Codes and Standards Sector shall ensure that codes and standards are published in SI units as determined by industry, government, and public needs.”

CSP-60 expands on the above as follows: “The code or standard shall state whether or not the use of the units of the alternative system can be used to comply with the provisions of the code or standard or if they are included for information only. Codes and standards published after June 2008 shall comply with this policy. Exceptions to this policy are permitted when a separate SI version of the code or standard exists or when the code or standard is written for applications where only non-SI units will be used.”

If writing a code or standard presenting values in both U.S. Customary (English) and International System (SI) units, adhere to the following guidelines:

(a) In text, tables, and figures, enclose the secondary units in parentheses following the primary units. However, do not provide parenthetical values in equations; rather, include parallel equations [see [SG3-3.1\(b\)](#)].

(b) You may include factors for converting U.S. Customary values to SI or vice versa in an appendix or in the general notes of figures and tables.

PART II

EDITORIAL STYLE GUIDE (SG)

SUBPART SG1

GENERAL STYLE RULES

SG1-1 CAPITALIZATION

Excessive capitalization exhausts the user and hinders consistency within and across standards.¹ Therefore, ASME style makes few exceptions for capitalizing words other than proper nouns and words that begin a sentence. Limit capitalization as follows:

(a) Do capitalize the following:

(1) true proper nouns such as personal names, words derived from personal names, and official place names.

EXAMPLES:

Fahrenheit (°F), Celsius (°C), and Rankine (°R), *but* kelvin (K), joules (J), and newton (N)]

Three Mile Island, *but* the Three Mile Island nuclear power plant

(2) the following words within cross-references:

(-a) “Standard” or “Code” when referring to the book itself (e.g., “This Standard covers the following equipment ...”)

(-b) words that refer to a labeled book element (e.g., Chapter 1, this Chapter; Part 5, this Part; Article 2000, this Article; Mandatory Appendix IV, this Appendix).

EXCEPTION: Do not capitalize “figure” or “table” when referring to “this figure” or “this table.”

See [SG2-2.9.3.3](#) for additional style rules for cross-references.

(3) the following words in titles set in headline style (i.e., Uc/lc): nouns, pronouns, verbs, adjectives, and adverbs, and any preposition or conjunction of four or more letters. See also [\(4\)](#) and [\(b\)\(4\)](#).

EXAMPLE:

Figure UG-53.3

Example of Tube Spacing With Pitch of Holes
Unequal in Every Second Row

(4) article “a,” “an,” or “the” if it is the first word in a title set Uc/lc [see [\(3\)](#)].

(b) Do not capitalize the following:

(1) terms defined in the definitions section unless the term is a proper noun

(2) the definition of an acronym or initialism unless the spelled-out term includes or is a proper noun (see [SG1-2.3](#) for additional style rules for acronyms and initialisms)

(3) prepositions or conjunctions of three or fewer letters in titles set Uc/lc [see [\(a\)\(3\)](#)]

(4) abbreviations of units of measure in titles

EXAMPLE:

Table UCS-56.1-1

Dimensions of Class 125 90-deg and 45-deg Elbows and Tees

See [SG2-2.2.2](#) for capitalization rules for breakdowns.

SG1-2 ABBREVIATIONS

SG1-2.1 Units of Measure

(a) Abbreviate units of measure only in the following contexts:

(1) when preceded by a quantity

(2) when specified in nomenclature (see [SG3-5](#))

(3) when specified in table column headings [see [SG4-2.4.1\(c\)\(3\)](#)]

EXCEPTIONS: Do not abbreviate “day,” “week,” or “month.”

See [Mandatory Appendix I](#) for C&S Publishing’s list of units of measure commonly used in ASME standards and the associated abbreviations. If using a unit of measure not shown in [Mandatory Appendix I](#), spell out the unit at the first occurrence in text and enclose the abbreviation in parentheses [e.g., 12 nanomolars (nM)]. Use the abbreviation thereafter in the contexts listed in [\(1\)](#) through [\(3\)](#).

(b) Express unit abbreviations in the singular regardless of the accompanying quantity (e.g., 1 ft, 6 hr, 8 in., 2 yr).

(c) Separate the unit from the quantity by a word space (e.g., 27 m, 487 ksi). See [SG1-3.2\(a\)\(2\)](#) for style rules regarding hyphenation of quantities and units of measure. See [SG3-3.2\(c\)](#) and [SG3-3.2\(d\)](#) for style rules regarding spacing of degree signs and percent signs, respectively.

(d) If expressing multiple values, repeat the unit or symbol (e.g., 1 in. to 2 in.; 0% to 10%; 32°F to 212°F).

(e) If expressing dual values modified by an operational sign, repeat the operational sign [e.g., <2 in. (<50 mm)]. See also [WG3-9\(a\)](#) and [SG3-3.2\(b\)](#).

¹ Throughout Part II, the word “standard” denotes a code or a standard. The style rules in [Subparts SG1](#) through [SG5](#) apply equally to ASME codes and standards.

(f) If expressing a limit, abbreviate “maximum” or “minimum” as “max.” or “min.” respectively, after the unit (e.g., 3 ft min., 10 deg max.). See also [SG3-3.3\(b\)](#) and [SG4-2.4.1\(d\)\(2\)](#) for additional rules affecting “maximum” and “minimum.”

(g) In figure captions, table column headings, and similar contexts, use a comma, not a preposition, before the unit abbreviation (e.g., “... for High Alloy Steel, ksi,” not “... for High Alloy Steel in ksi”).

SG1-2.2 References

(a) In reference-list citations, abbreviate the following terms:

(1) “editor” as “Ed.” (plural: “Eds.”) if citation includes an editor

(2) “edition” as “ed.” if citation includes an edition number

(3) “volume” as “Vol.” (plural: “Vols.”) if citing a specific volume of a book

(4) “page” as “p.” (plural: “pp.”) if citing a specific page number of a book

See [SG2-2.9.2.1](#) through [SG2-2.9.2.3](#) for additional style rules for reference-list citations.

(b) If referencing specific paragraphs and equations in text, abbreviate the following terms before the numerical designator unless the cross-reference begins a sentence:

(1) “paragraph” as “para.” (plural: “paras.”)

(2) “equation” as “eq.” (plural: “eqs.”)

See [SG2-2.9.3.3](#) for additional style rules for cross-references.

SG1-2.3 Acronyms and Initialisms

Acronyms and initialisms (e.g., NASA, PTC) save both time and space. However, if undefined and overused, such abbreviations can create ambiguity and exhaust the user. Adhere to the following style rules:

(a) Limit use of acronyms and initialisms to terms that are widely used in the standard (five or more occurrences) or widely accepted in the industry the standard applies to.

(b) Define acronyms and initialisms as follows:

(1) *Within the Definitions Section*

(-a) If the full term is listed as an entry in the definitions section, spell out the full term and enclose the acronym or initialism in parentheses immediately after.

EXAMPLE:

phase-angle correction factor (PACF): ratio of the true power factor to the measured power factor. The phase-angle correction factor corrects for the phase displacement of the secondary current or voltage, or both, due to the instrument transformer phase angle.

(-b) Use the full term, not the acronym or initialism, in each definition in which the term is mentioned. See the example in [\(-a\)](#). This rule ensures the user can understand each definition without having to seek out yet another definition.

(-c) If the standard comprises multiple chapters or uses multiple (approximately five or more) acronyms and initialisms, include a list of abbreviations after the main definitions list. See [Example SG1.1](#). The list will provide a quick reference for the user. The list may be in addition to or in lieu of entries in the definitions list [see [\(-a\)](#)].

(2) *In Paragraph Headings.* Do not define an acronym or initialism in a paragraph heading. If the heading introduces the term, spell out the full term in the heading and define the acronym or initialism in the running text that follows [see [\(3\)](#)]. If the term has been previously defined in running text, use the acronym or initialism in the heading.

(3) *In Text Other Than Definitions.* Outside the definitions section, spell out the full term at first usage in running text and enclose the acronym or initialism in parentheses immediately after. After this first usage, use the acronym or initialism exclusively.

(c) Do not capitalize the definition of an acronym or initialism unless the spelled-out term includes or is a proper noun. See [SG1-1](#) for capitalization rules.

(d) Treat the acronym or initialism as either a singular or a plural noun depending on the definition.

(1) If the definition of the acronym or initialism is singular, treat the acronym or initialism as singular. Use a singular verb if the acronym or initialism is the subject of a clause. Add “s” to make the acronym or initialism plural.

EXAMPLE:

A performance test code (PTC) provides helpful testing information. ASME PTCs are widely used in industry.

(2) If the definition of the acronym or initialism is plural, treat the acronym or initialism as plural. Use a plural verb if the acronym or initialism is the subject of a clause. Do not add “s” to the acronym or initialism to make it plural — it is already plural per the definition. Do not use the article “a” or “an” or a singular adjective (e.g., “each,” “one”) with an acronym or initialism that represents a plural.

EXAMPLE:

The operating company shall develop operation and maintenance procedures for covered piping systems (CPS). CPS include the following components: ...”

Note that acronyms and initialisms defined in the plural can lead to awkward and unclear sentences. Best practice is to define in the singular.

SG1-3 PUNCTUATION

SG1-3.1 Commas and Semicolons

(a) Use commas to separate the items in a series of three or more items. Use semicolons if even one of the items in the series includes a comma.

EXCEPTION: Use commas, not semicolons, to separate multiple author names in a reference-list entry [see SG2-2.9.2.3(a)(1)(-a)].

(b) Use a comma immediately after an introductory phrase or clause.

(c) Use a comma before *and* after a nonrestrictive clause [see SG1-7.3(a)].

(d) Use commas, not parentheses, to separate a variable from its definition in text (e.g., “The thickness, t , shall be greater than the length, L ”). Note that when the variable acts in apposition, no commas are needed (e.g., “Lengths L and L_2 are less than thicknesses t_x and t_y ”).

SG1-3.2 Hyphens and Dashes

(a) Hyphenate the following:

(1) a compound adjective preceding the noun it modifies [but see also (c)]

EXAMPLES:

corrosion-resistant coating, *but* the coating shall be corrosion resistant

four-wheel drive

pressure-retaining vessel

(2) a quantity and unit of measure when the two precede the noun they modify (e.g., 2-mm thickness, *but* the thickness shall not exceed 2 mm)

(3) noninclusive numbers (e.g., telephone numbers)

(4) fractions when spelled out (e.g., one-third; see also SG3-2.2)

(5) table, figure, equation, and some paragraph designators [see SG2-2.1.2, SG3-3.4.2(b), SG4-2.2, and SG5-3(b)]

(b) Do not hyphenate words formed with prefixes (e.g., anti, bi, co, inter, mid, multi, non, over, post, pre, pro, re, semi, sub, super, trans, un, under) except in the following contexts:

(1) The prefix stands alone (e.g., “The over- or underestimation can lead to ...”).

(2) The prefix causes a repetition of vowels (e.g., semi-isolated).

(3) The prefix is combined with a capitalized word or numerals (e.g., non-ASME, mid-1900s).

(4) The combination of prefix and root word could be misread (e.g., co-edition).

(5) The word is listed in Merriam-Webster’s Unabridged Dictionary² as a hyphenated term (e.g., re-collect, meaning to *gather again*).

(6) The prefix “non” precedes a hyphenated compound adjective to negate the compound adjective (e.g., non-pressure-retaining equipment, meaning *equipment that does not contain pressure*).

(c) Do not hyphenate a compound adjective formed from an adverb ending in “-ly” (e.g., fully annealed ends).

(d) Use an en dash (–) in the following contexts:

(1) to indicate a range of numbers in tables (e.g., 12–24). In text, use “to” or “through,” never “thru.”

(2) to indicate the edition year of a book whose designator contains a hyphen (e.g., ASME CSD-1-2021).

(3) to indicate components (e.g., Ni–Cr–Fe).

(4) to indicate an equal or bidirectional relationship between words or phrases (e.g., pressure–temperature, stress–strain, elastic–plastic).

(e) Use an em dash (—) surrounded by spaces to indicate a thought break, as in titles (e.g., Safety Controls for Fired Units: Gas Burners — Natural Draft; ISO 496, Measurement of fluid flow — Evaluation).

SG1-3.3 Parentheses, Brackets, and Braces

Set off parenthetical information using the following order of distinction: parentheses, then brackets enclosing parentheses, then braces enclosing brackets.

EXAMPLE:

[See para. 1.2(a).]

SG1-3.4 Quotation Marks

(a) Use quotation marks to indicate a word or term used as the word or term itself.

EXAMPLE:

The term “welded joint” is defined in the glossary.

(b) Enclose commas and periods within a closing quotation mark. Set colons and semicolons outside a closing quotation mark. Enclose a question mark or exclamation point inside a closing quotation mark only if the question mark or exclamation point is part of the quoted material.

SG1-3.5 Slashes

ASME style limits the use of slashes to official specification designators (e.g., ASTM 588/588M) and mathematical copy (e.g., fractions, division problems, abbreviated units of measure). Do not use slashes to replace the words “and” or “or” or the commas in a series of items. Do not use the expression “and/or.” See also SG1-7.5.

² Merriam-Webster’s Unabridged Dictionary is available at <https://www.merriam-webster.com/>.

SG1-3.6 Punctuation Within Breakdowns

See [SG2-2.2.2](#) for style rules for punctuating breakdowns.

SG1-3.7 Punctuation and Footnote or Endnote References

Place superscript footnote or endnote references after punctuation marks. See [Example SG1.2](#).

EXCEPTION: Place footnote or endnote references before em dashes and before the colons immediately following terms in a definitions section. See [Example SG1.3](#).

SG1-3.8 Punctuation and Equations

See [SG3-3.3](#) for style rules on punctuation within and surrounding equations.

SG1-4 SPELLING

Consult Merriam-Webster's Unabridged Dictionary¹ to confirm spellings. If Merriam-Webster's lists more than one spelling, use the primary rather than the variant spelling. For example, Merriam-Webster's lists "liquefy" as a variant of "liquefy." "Liquefy" is the primary spelling and therefore the correct spelling for an ASME standard.

SG1-5 PARENTHETICAL PLURALS

Do not use parenthetical plurals [e.g., vessel(s)]. Parenthetical plurals are imprecise and often compromise subject-verb agreement. If the intention is to capture the concept of "one or more," then state "one or more" or use the adjectives "each" or "any."

EXAMPLES:

Incorrect: **A drawing(s)** shall indicate the locations of the gauges on the pressure hull.

Correct: **One or more drawings** shall indicate ...

Incorrect: The **assembled panel(s)** shall be capable of withstanding a force of 2 500 N (560 lbf) with no permanent displacement or deformation.

Correct: **Each assembled panel** shall be capable ...

SG1-6 FOREIGN WORDS

Use roman type for foreign words and phrases defined in Merriam-Webster's Unabridged Dictionary.¹ Italicize foreign words not in Merriam-Webster's.

EXAMPLES:

a posteriori

a priori

fait accompli

quid pro quo

SG1-7 SIMILAR WORDS

SG1-7.1 "Shall" and "Must"

ASME policy dictates the use of "shall" to express a mandatory requirement of the standard (e.g., "Each trolley hoist shall have an identification marking ..."). Do not construct requirements using "must" or "is to be."

SG1-7.2 "Should" and "May"

(a) ASME policy dictates the use of "should" to express a recommendation, the advisability of which depends on the facts in each situation (e.g., "A warning device should be provided for installations ...").

(b) ASME policy dictates the use of "may" to denote a permission, which is neither a requirement nor a recommendation. Use "may" exclusively to express permission, not to express possibility. Use "might" or "could" to express possibility.

EXAMPLES:

The owner **may** designate a representative to carry out selected responsibilities.

In display labels, "EQ" **may** be substituted for "EARTHQUAKE."

The combination of excessively worn guide shoes and limit-switch rollers **might** cause cars to overrun their terminals.

High concentrations of alkalis **could** contribute to corrosion of certain apparatus.

SG1-7.3 "Which" and "That"

"Which" and "that" are relative pronouns with similar but not identical functions. Adhere to the following grammar rules:

(a) Use "which" to introduce a nonrestrictive clause, i.e., a clause containing information not essential to the sentence's meaning. Precede a nonrestrictive clause with a comma, and follow the clause with a comma unless the clause ends the sentence.

EXAMPLE:

When the design temperature exceeds 150°F, additional design considerations, **which** are not included in this Standard, are the responsibility of the tank designer.

(b) Use "that" to introduce a restrictive clause, i.e., a clause containing information essential to the sentence's meaning. Do not precede a restrictive clause with a comma.

EXAMPLE:

Repeat Step 1 with a corrugated or grooved-metal gasket **that** has graphite facing.

SG1-7.4 "Assure," "Ensure," and "Insure"

Although similar, the words "assure," "ensure," and "insure" have subtly different meanings.

(a) Use “assure” when the intended meaning is “dispel the doubt of” or “give confidence to” a person. Note that one assures a person, not a thing.

EXAMPLE:

The manufacturer shall **assure** the purchaser that the product meets all requirements.

(b) Use “ensure” when the intended meaning is “take steps to see that” or “make sure.”

EXAMPLE:

The training organization shall **ensure** that trainees have a thorough understanding of the requirements.

EXCEPTION: ASME NQA-1 uses “assure” rather than “ensure” in the context of quality assurance.

(c) Use “insure” only in reference to financial matters of insurance.

SG1-7.5 “And,” “Or,” and “And/Or”

(a) Do not use the expression “and/or,” which leaves the user to interpret the intended meaning of the sentence. Use either “and” or “or” depending on the context.

EXAMPLES:

The construction requires the use of elbows **and** tees.

The construction requires the use of elbows **or** tees.

The construction requires the use of elbows **or** tees, **or** both.

(b) When all the items in a series connected by “or” are singular, use a singular verb. When all the items are plural, use a plural verb. When the items do not agree in number, use the verb form that agrees with the item nearest the verb.

EXAMPLES:

An elbow or a tee **is** required in the construction.

Elbows or tees **are** required in the construction.

A tee or two elbows **are** required in the construction.

NOTE: In sentences in which the items in a series do not agree in number, a plural item nearest the verb often reads better than a singular item nearest the verb. See last example above.

SG1-8 ADJECTIVES AND ADVERBS

Adjectives and adverbs can enhance meaning and clarify description. However, overmodification can lead to confusion, especially when multiple modifiers are not coherently ordered and hyphenated. Consider the phrase “metric break mandrel open end blind rivets.” The relationships among the words is unclear. Revising to “open-end blind rivets for break mandrels, metric series” clarifies the subject and alleviates misinterpretation about breaking open mandrels. In addition, qualifying words that are not specific lead to ambiguity. For example, how is the user to interpret “a suitable method of test” or “a sufficiently reinforced plate” if there are no requirements

that define what is suitable or sufficient? Choose modifiers carefully to ensure they are meaningful.

See [SG1-3.2](#) for style rules on hyphenating adjectives and adverbs.

SG1-9 SYNONYMS

Use synonyms, particularly synonyms of technical terms, carefully. A standard should not refer to a “particle counter” one time, “the counter” a second, and “the instrument” a third. Although restating the same term can become repetitive, use of consistent terms reduces the risk of confusing the user. Conversely, each term should have a unique meaning. Do not use the same term to refer to more than one thing, even if the context seems to differentiate meaning. See [SG2-2.4.3\(a\)](#) for style rules on defining synonyms in the definitions section.

SG1-10 PERSONAL PRONOUNS

Do not use gendered pronouns (i.e., *he, she, he/she, his, her, his/her, him, him/her, himself, and herself*) for generic references to people. Do not replace singular gendered pronouns with plural *they* or *them*.

When writing new standards or new sections of existing standards, avoid using personal pronouns, including gender-neutral *it, they, and them*, entirely. Carefully crafted sentences will not require pronouns.

When revising existing standards, review the text for gendered pronouns and revise to gender-neutral language.

SG1-10.1 Techniques for Eliminating Gendered Pronouns

The following techniques for eliminating gendered pronouns are excerpted and adapted from the Chicago Manual of Style (CMS), 17th edition, 5.255.³ CMS advises that “no single method will work for every writer or in every context. Choose the combination of methods that works best in the context you’ve created.”

(a) *Omit the pronoun.* Sometimes a personal pronoun is not really necessary. Review the following examples:

EXAMPLE 1:

Gendered: The Certificate Holder may subcontract to another organization the surveying and auditing of **his** subcontractors and Material Organizations.

Gender Neutral: The Certificate Holder may subcontract to another organization the surveying and auditing of subcontractors and Material Organizations.

³The Chicago Manual of Style (17th edition) (2017). University of Chicago Press. <https://doi.org/10.7208/cmso17>

EXAMPLE 2:

Gendered: The Certificate Holder shall have contractual control of the welding operation, including authority to assign or remove welders and welding operators **at his discretion**.

Gender Neutral: The Certificate Holder shall have contractual control of the welding operation, including authority to assign or remove welders and welding operators.

EXAMPLE 3:

Gendered: The owner shall give **his** approval for the lubricants that could come in contact with the process.

Gender Neutral: The owner **shall approve** the lubricants that could come in contact with the process.

Note that in Example 2, “authority” indicates discretion; therefore, “at his discretion” is unnecessary and can be deleted.

Note that in Example 3, “his” is not needed because the possessor of “approval” is obvious — whose approval would the owner give other than the owner’s own? Note also that using the verb “approve” rather than the verb phrase “give approval” creates a tighter, more direct sentence.

(b) *Repeat the noun.* In many contexts, repeating the noun provides a simple solution for eliminating a pronoun. Review the following examples:

EXAMPLE 1:

Gendered: Neither the inspector nor **his** employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Gender Neutral: Neither the inspector nor **the inspector’s** employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

EXAMPLE 2:

Gendered: The Manufacturer may perform Code welding using the services of individual welders who are not in **his** employ provided all the following conditions are met.

Gender Neutral: The Manufacturer may perform Code welding using the services of individual welders who are not in **the Manufacturer’s** employ provided all the following conditions are met.

(c) *Use an article instead of a pronoun.* Try replacing the singular personal pronoun with a definite or indefinite article. Quite often you’ll find that the effect on the sentence’s meaning is negligible. Review the following examples:

EXAMPLE 1:

Gendered: Any such legal requirement shall not relieve the owner of **his/her** inspection responsibilities specified in para. 136.1.

Gender Neutral: Any such legal requirement shall not relieve the owner of **the** inspection responsibilities specified in para. 136.1.

EXAMPLE 2:

Gendered: The Inspector shall present **his/her** inspection report along with any findings to the Certified Individual.

Gender Neutral: The Inspector shall present **an** inspection report along with any findings to the Certified Individual.

(d) *Use the relative pronoun “who.”* This technique works best when it replaces a personal pronoun that follows “if.” It also requires revising the sentence slightly. Review the following example:

EXAMPLE:

Gendered: Employers presume that **if an applicant can’t write well, he** won’t be a good employee.

Gender Neutral: Employers presume **that an applicant who can’t write well** won’t be a good employee.

(e) *Use the imperative mood.* The imperative eliminates the need for an explicit pronoun. Although use of the imperative, i.e., command statements, will likely be limited in ASME standards, you may find that it avoids wordiness and more forcefully addresses the target audience. Review the following example:

EXAMPLE:

Gendered: He shall verify that the manufacturer or installer has the required Certificate of Authorization to construct the items.

Gender Neutral: Verify that the manufacturer or installer has the required Certificate of Authorization to construct the items.

(f) *Revise the sentence.* If the techniques in (a) through (e) do not produce a sentence that reads well, rewrite the sentence. The amount of revision will vary. Review the following examples:

EXAMPLE 1:

Gendered: The employer shall maintain a record (WPS and/or WPQ) signed by **him/her**, and available to the purchaser or **his/her** agent and the inspector, of the WPSs used and the welders and/or welding operators employed by **him/ her**, showing the date and results of procedure and performance qualification.

Gender Neutral: The employer shall sign and maintain a record of the WPSs or WPQs used and the welders or welding operators employed. The record shall show the date and results of procedure and performance qualification. The employer shall make the record available to the purchaser or purchaser’s agent and the inspector.

EXAMPLE 2:

Gendered: The employer shall be responsible for qualifying any WPS that **he/she** intends to have used by personnel of **his/her** organization.

Gender Neutral: The employer shall qualify any WPS used by the employer’s personnel.

EXAMPLE 3:

Gendered: Ask the individual (e.g., operator, inspector, and maintenance technician) to tell you **“his story”** about **his** experience with the component.

Gender Neutral: Ask about the individual’s experience with the component.

SG1-10.2 Additional Resources

Consult the following resources for additional guidance and information on inclusive language:

(a) Guidance for NIST Staff on Using Inclusive Language in Documentary Standards, <https://nvlpubs.-nist.gov/nistpubs/ir/2021/NIST.IR.8366.pdf>

(b) American Psychological Association's Style and Grammar Guidelines: General Principles for Reducing Bias, <https://apastyle.apa.org/style-grammar-guidelines/bias-free-language>

SUBPART SG2

STYLE RULES FOR THE ELEMENTS OF AN ASME STANDARD

SG2-1 FRONT MATTER

See [WG2-2.1](#) for descriptions of front matter elements. The copyright and correspondence pages comprise boilerplate text and therefore are not covered in [Subpart SG2](#).

SG2-1.1 Title Page

The C&S Publishing XML system autogenerates the title page. The title page is identical to the front cover but with the addition of ASME's New York address in the logo block at the bottom of the page.

SG2-1.2 Table of Contents

The C&S Publishing XML system autogenerates the table of contents. The table of contents includes the following elements, listed as ordered below:

- (a) all front matter elements
- (b) division, part, chapter, or section titles; subdivision, subpart, or subsection titles; and first-level headings
- (c) all mandatory and nonmandatory appendices
- (d) all figures, tables, and forms
- (e) endnotes and index, if any

If the standard includes only a single appendix, figure, table, or form, revise the boldface heading preceding the individual listing to singular. For example, **Mandatory Appendices** becomes **Mandatory Appendix** if there is only one mandatory appendix.

SG2-1.3 Committee Roster

The C&S Publishing XML system formats committee rosters as shown in [Example SG2.1](#) or [Example SG2.2](#). Apply the following style rules to the roster entries:

(a) Committee Members

(1) Alphabetize officers and members by last name. Group the following supplementary member types, in the order shown, after the main members. Alphabetize the members within each grouping.

Delegate

Alternate

Ex-Officio Member

Contributing Member

Honorary Member

(2) Include a space between the initials of committee member names.

(3) Surround abbreviations "Jr." and "Sr." with commas: **A. B. Smith, Jr., Chair.**

(b) Company Names

(1) Abbreviate the following terms if used as part of a company name:

Term	Abbreviation
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
Limited liability company	LLC
Limited partnership	LP
Public limited company	PLC

(2) Precede "Inc.," "Ltd.," "LLC," "LP," and "PLC" with a comma.

(3) If a company website uses an ampersand (&) rather than the word "and" in the company name, use the ampersand in the roster listing. If a company name includes two initials joined by an ampersand, leave no space around the ampersand (e.g., S&B Engineers and Constructors, Ltd.).

SG2-1.4 SOC

C&S Publishing's XML system autogenerates the SOC based on editor-defined margin designator processing instructions (see [SG2-2.7](#) for information on margin designators). Format the *Change* or *Change (Record)* entries as follows:

(a) Express each change in past tense, e.g., "Revised," "Added," "Deleted." Omit end punctuation.

(b) Include the minimal amount of information needed to describe the change. Often a single-word description, e.g., "Revised," "Added," "Deleted," suffices. However, the following contexts require additional detail. Items (1) through (3) describe guidelines, not rigid principles. Consult the Managing Editor with questions regarding change descriptions.

(1) If the change is an editorial change initiated by C&S Publishing, use the phrase "Editorially revised."

(2) If the change involves redesignation and revision of multiple paragraphs or affects more than 50% of a paragraph, table, etc., use the phrase "Revised in its entirety."

(3) If the change is due to errata, include details pinpointing the correction and describe the change as "corrected by errata" (e.g., "In eq. (4), '1.118 in.²' corrected by errata to '1.118 in.'").

(c) If multiple changes affect a single location, number the changes (1), (2), (3), etc. Begin each item on a new line.

(d) If the standard includes an LOC, end each *Change (Record)* description with the record numbers italicized in parentheses, e.g., (18-2697, 19-2365).

See [Examples SG2.3](#) and [SG2.4](#).

SG2-1.5 LOC

Format entries for an LOC as follows:

(a) List the record numbers numerically in the *Record Number* column.

(b) Edit each entry in the *Change* column to express the changes in past tense and to comply with the style rules in [Subparts SG1](#) and [SG2](#). End each entry with a period.

See [Example SG2.5](#).

SG2-2 MAIN TEXT

See [WG2-2.2](#) for descriptions of main text elements.

SG2-2.1 Paragraph Headings

SG2-2.1.1 Nonchapter Standards. Format the paragraph headings of nonchapter standards as follows:

(a) *First-Level Headings.* Designate first-level headings with single digits, i.e., 1, 2, 3, etc. Provide a title for each first-level heading. Set the title all uppercase.

(b) *Second-Level Headings*

(1) Designate second-level headings using the first-level designator followed by a period and a numeral, e.g., 1.1, 1.2, 1.3. Provide a title for each second-level heading. Set the title Uc/lc [see [SG1-1\(a\)\(3\)](#)].

(2) Use second-level headings only if you are designating two or more paragraphs as subordinate to the first-level paragraph. For example, do not designate a paragraph as 1.1 if there is no subsequent para. 1.2. Such designation is unnecessary and potentially confusing to the user, who is left to wonder where the subsequent second-level paragraphs are.

(c) *Third- and Fourth-Level Headings*

(1) Designate third- and fourth-level headings using the same method as for second-level designators, adding periods and numerals to indicate the subsequent levels, e.g., 5.1.1 for a third-level heading, 5.1.1.1 for a fourth-level. You may omit titles for third- and fourth-level headings. However, if you title one third- or fourth-level heading, then you must title all headings within that level grouping. For example, if para. 5.1.1 has a title, then paras. 5.1.2 and 5.1.3 must have titles. Set the title Uc/lc [see [SG1-1\(a\)\(3\)](#)]. End each title with a period unless the heading immediately precedes a lower-level heading or a breakdown.

(2) Use third- and fourth-level headings only if you are designating two or more paragraphs as subordinate paragraphs. For example, do not designate a paragraph as 1.1.1 if there is no subsequent para. 1.1.2. See [SG2-2.1.1\(b\)\(2\)](#) for more information.

SG2-2.1.2 Multichapter Standards. Format the headings of multichapter standards as follows:

(a) *First-Level Headings.* Designate first-level headings using the Chapter or Section number followed by a hyphen and a numeral, e.g., 1-1, 1-2, 1-3. Provide a title for each first-level heading. Set the title all uppercase.

(b) *Second-Level Headings*

(1) Designate second-level headings using the first-level designator followed by a period and a numeral, e.g., 1-1.1, 1-1.2, 1-1.3. Provide a title for each second-level heading. Set the title Uc/lc [see [SG1-1\(a\)\(3\)](#)].

(2) Use second-level headings only if you are designating two or more paragraphs as subordinate to the first-level paragraph. See [SG2-2.1.1\(b\)\(2\)](#) for more information.

(c) *Third- and Fourth-Level Headings*

(1) Designate third- and fourth-level headings using the same method as for second-level designators, adding periods and numerals to indicate subsequent levels, e.g., 5-1.1.1 for a third-level heading, 5-1.1.1.1 for a fourth-level. You may omit titles for third- and fourth-level headings. See [SG2-2.1.1\(c\)\(1\)](#) for details and additional style rules.

(2) Use third- and fourth-level headings only if you are designating two or more paragraphs as subordinate paragraphs. See [SG2-2.1.1\(b\)\(2\)](#) for more information.

SG2-2.2 Breakdowns

SG2-2.2.1 General

(a) Use a breakdown only if creating a list of two or more items. For example, do not designate a sentence or phrase as (a) if there is no subsequent (b). Such designation is potentially confusing to the user, who is left to wonder where the subsequent items are.

(b) Label breakdowns alphanumerically as follows:

(1) first-level breakdowns: (a), (b), (c), etc. After (z), use two letters: (aa), (bb), etc.

(2) second-level breakdowns: (1), (2), (3), etc.

(3) third-level breakdowns: (-a), (-b), (-c), etc.

(4) fourth-level breakdowns: (-1), (-2), (-3), etc.

(5) fifth-level breakdowns: (+1), (+2), (+3), etc.

(6) sixth-level breakdowns: (+a), (+b), (+c), etc.

NOTE: Fifth- and sixth-level breakdowns can result in long, unwieldy lists. Use these levels rarely or omit them. Consider alternative designations, such as third- or fourth-level paragraph headings [see [SG2-2.1.1\(c\)](#) and [SG2-2.1.2\(c\)](#)].

(c) Indent the first line of breakdown items based on the breakdown level: indent once for first-level items, twice for second-level items, three times for third-level items, etc.

(d) Include only one first-level breakdown within each designated paragraph. For example, within UIG-2, there can be only one (a), only one (b), and so on. You may include lower-level breakdowns within each first-level breakdown item, but you may not end a first-level

breakdown and begin a new first-level breakdown. This rule ensures unique paragraph designators for easy cross-referencing. Without this rule, a standard might have two or more paragraphs with the same designation, for example, two paragraphs identified as “UIG-2(a).” The rule applies also to lower-level breakdowns within a higher-level breakdown item. For example, within UIG-2(a), there can be only one (1), one (2), and so on. Within UIG-2(a)(1), there can be only one (-a), only one (-b), and so on.

SG2-2.2.2 Punctuation and Capitalization. Items in a breakdown must be parallel in construction — that is, all phrases or all sentences. A standard may include a mix of phrase- and sentence-style lists, but it is always the lead-in sentence or phrase that determines the punctuation preceding a particular list and the punctuation and capitalization within the list. Here are the basic guidelines.

(a) *Lead-Ins*¹

(1) Use a colon after an introductory statement that contains the words “as follows” or “the following.” Use a period after other statements introducing lists. See [Examples SG2.6](#) and [SG2.7](#).

(2) If the introduction to the breakdown is a sentence fragment (i.e., not a complete sentence), end the fragment with no punctuation. See [Example SG2.8](#).

(b) *Within Breakdowns*

(1) If the breakdown items that follow a sentence fragment

(-a) are not complete sentences, begin each item with a lowercase letter and end the item with no punctuation, regardless of whether the item itself contains commas or any other punctuation. See [Example SG2.9](#).

(-b) include one item that itself includes a complete sentence and therefore requires a period, then end each item in the list, including phrases, with a period. Begin each breakdown item with a lowercase letter. See [Example SG2.8](#).

(2) If the breakdown items that follow a complete introductory sentence are complete sentences, begin each item with an uppercase letter and end each with a period. See [Example SG2.7](#). If the breakdown items are fragments, follow the rules in (1)(-a) and (1)(-b).

NOTE: Whether complete sentences or fragments, breakdown items must flow logically from the sentence or sentence fragment that introduces the breakdown. One technique for checking breakdowns is to read aloud the sentence or fragment that introduces the breakdown and then read the first breakdown item. If the two pieces do not make sense when read together, either the phrasing is wrong or the relationship between the introduction and the item is flawed. Repeat the process for each item in the breakdown list. Rephrase either the introduction or the items so that each item flows logically from the introduction. If rephrasing doesn’t resolve the issues, assess whether each item belongs in the breakdown. Some items might need to be set as sentences or paragraphs separate from the breakdown.

SG2-2.2.3 Titles. Breakdowns may include titles. If one breakdown item has a title, all breakdown items within the same level must have titles. Format breakdown titles as follows:

(a) Italicize the title and capitalize per [SG1-1](#).

(b) Run the title in with the text unless the text immediately following the title begins a next-level breakdown. If the title runs in with the text, end the title with a period. If the title stands alone on the line, end the title with no punctuation.

See [Example SG2.10](#).

SG2-2.3 Procedures and Instructions

Format procedures, instructions, and similar lists of ordered actions as steps. You may list steps immediately after a designated paragraph heading, a breakdown title, or an introductory statement. Format the steps as follows:

(a) Phrase each step as a command statement and end it with a period.

(b) List the steps in the order in which the user must perform them.

(c) Label and number each step: *Step 1*, *Step 2*, etc. Set the label and number italic and follow the number with a period. Run the label in with the text.

See [Example SG2.11](#).

SG2-2.4 Terms and Definitions

SG2-2.4.1 Terms

(a) Alphabetize terms using the letter-by-letter method. See [SG2-2.4.5](#).

(b) Italicize each term. Set the term lowercase unless the term is a proper noun. Follow the term with a colon and then state either the definition or a cross-reference to another term. See [Example SG2.12](#).

(c) Do not include parenthetical synonyms or descriptors after the term. The term that precedes a definition should be precisely the term used in text. See [SG2-2.4.3\(a\)](#) for treatment of synonyms. See also [SG1-2.3\(b\)\(1\)](#) for treatment of acronyms and initialisms.

(d) Do not designate the terms. ASME Y14 standards, which do designate terms in the definitions section, are the only exceptions to the rule.

NOTE: When using defined terms within the body of the standard, set the terms roman, not italic.

SG2-2.4.2 Definitions

(a) Set definitions roman. Begin each definition with a lowercase letter and end with a period, regardless of whether the definition is a complete sentence. Definitions may consist of more than one sentence. See [Example SG2.13](#).

(b) If a single term has multiple definitions, label the definitions (a), (b), etc., and begin each definition on a new line. See [Example SG2.14](#).

¹Section SG2-2.2.2 was adapted from *The Editorial Eye*, Vol. 19, No. 4.

(c) A breakdown may occur within a definition. In such cases, follow the rules for breakdowns in [SG2-2.2](#). See [Example SG2.15](#).

SG2-2.4.3 Synonyms and Subterms

(a) *Synonyms*. If two terms have the same definition, present the definition at the listing for the primary term, i.e., the term preferred in the standard. List the synonym alphabetically and provide a cross-reference to the primary term in lieu of a definition: “see *primary term*.” Alternatively, you may omit a separate listing for the synonym and end the definition of the primary term with “Also called *synonym*.” You may choose to implement both methods for synonyms. See also [SG1-9](#) and [Example SG2.16](#).

(b) *Subterms*. List subterms immediately after the primary term. Indent each subterm one em space to distinguish it as a subterm. Alphabetize the subterms. See [SG2-2.4.5](#) and [Example SG2.17](#).

SG2-2.4.4 Citing Defined Terms Within a Definition.

Within a definition, italicize terms in cross-references to other defined terms (e.g., “See also *term*”) and in synonym-defining statements (e.g., “Also called *term*”).

NOTE: Do not italicize terms outside of the definitions section, even if preceded by the verb “called” (e.g., “This phenomenon is often called water hammer”).

SG2-2.4.5 Alphabetization

(a) Alphabetize terms letter by letter, ignoring hyphens, slashes, spaces, and apostrophes. The order of precedence is as follows: one word; word followed by an open parenthesis; word followed by a comma; then (ignoring spaces and other punctuation) word followed by a number; and word followed by a letter.

(b) List terms beginning with a numeral in numerical order before terms beginning with a letter. List terms followed by a numeral first alphabetically and then numerically (e.g., “Group Number 4” precedes “P-Number 1”; “Schedule 40” precedes “Schedule 80”).

(c) If two or more terms are inverted to stress a common base word, first list the base word on its own line. Then list the inverted terms alphabetically, indented as subterms below the base word. See *brake* in the example below.

The following example shows a list of terms alphabetized letter by letter:

EXAMPLE:

B30 Volumes
B31 pressure piping
back-connected
back end
back-feed
back focal distance
BA series
Ba series

blister
blister, polymeric
blistering
bookcase
book-form drawing
bookrack
booster 2
booster 11
booster A
booster a
boost rocket
brake
brake, drag
brake, friction belt
brake, friction-type
brake, holding
brake, parking
brakeless
brake means
braking, power
brakingless

SG2-2.5 Notes

SG2-2.5.1 In-Text Notes. In-text notes are separated from the paragraph to convey emphasis. They are set flush left and in smaller type than regular text.

(a) *Single In-Text Note*. Precede a single in-text note with the label “NOTE:” and run the text of the note into the line. See [Example SG2.18](#).

(b) *Multiple In-Text Notes*. Precede multiple in-text notes with the label “NOTES:” set flush left on its own line. Number the notes (1), (2), etc., and begin each on a new line. The C&S Publishing XML system aligns run-over lines on the first word of the note. See [Example SG2.19](#).

(c) *Text Elements Within In-Text Notes*. In-text notes may contain paragraphs, breakdowns, equations, and in-text tables. Follow the style rules in [SG2-2.2](#), [SG3-3](#), and [SG4-3](#).

SG2-2.5.2 Footnotes. The C&S Publishing XML system places footnotes at the bottom of the page, under the column where the footnotes are first referenced. A 3-pica rule, flush left, appears directly above the footnotes. If a footnote runs over to the next column in a snaking fashion, a rule separates the run-over footnote text from the last line of text in the second column. The XML system indents the first line of the footnote one em space and sets run-over text flush left.

(a) *Front Matter*. In front matter, use an asterisk (*) for the first footnote and double-asterisk (**) for the second footnote. If there are more than two footnotes, use numerals. See [Example SG2.20](#).

(b) *Main Text and Back Matter*. Number footnotes consecutively beginning with a superscript “1” in each new chapter, part, division, or appendix. Number footnotes in the order in which they are referenced in text.

(c) *Placement of Footnote References.* Place the footnote reference immediately after and closed up to the text to which it applies. Place the footnote reference after punctuation marks except em dashes and the colons following terms in a definitions section.

(d) *Multiple Footnote References*

(1) If the same footnote is referenced at more than one location within the same chapter, part, etc., cite the footnote number at each location. Do not repeat the footnote.

(2) If the same footnote is referenced in more than one chapter, part, etc., repeat the footnote in each chapter or part, numbering the footnote consecutively among the other footnotes within the chapter or part.

(e) *Breakdowns Within Footnotes.* Format breakdowns in footnotes per the breakdown style rules in [SG2-2.2](#).

SG2-2.5.3 Endnotes

(a) *Location of Endnotes Listing.* List endnotes after the last nonmandatory appendix. Title the listing “ENDNOTES.” See [Example SG2.21](#).

(b) *Front Matter.* Do not use endnotes in the front matter. Use footnotes. See [SG2-2.5.2\(a\)](#).

(c) *Main Text and Back Matter.* Number endnotes consecutively beginning with a superscript “1.” Number the endnotes in the order in which they are referenced in text.

(d) *Placement of Endnote References.* Place endnote references in the same manner as footnote references. See [SG2-2.5.2\(c\)](#).

(e) *Multiple Endnote References.* If the same endnote is referenced at more than one location, cite the endnote number at each location.

(f) *Breakdowns Within Endnotes.* Format breakdowns in endnotes per the breakdown style rules in [SG2-2.2](#).

SG2-2.6 Exceptions, Examples, Warnings, and Cautions

SG2-2.6.1 Exceptions. Format exceptions in the same manner as in-text notes (see [SG2-2.5.1](#)). Use the label “EXCEPTION” instead of “NOTE.”

SG2-2.6.2 Examples. Format examples in the same manner as in-text notes (see [SG2-2.5.1](#)). Use the label “EXAMPLE” instead of “NOTE.” If the example contains many text elements (breakdowns, equations, nomenclature, etc.), set the example in 10-point font for better readability.

SG2-2.6.3 Warnings and Cautions. Format warnings and cautions in the same manner as in-text notes (see [SG2-2.5.1](#)). Use the label “CAUTION” or “WARNING”

instead of “NOTE.” The C&S Publishing XML system sets cautions and warnings in bold.² See [Example SG2.22](#).

SG2-2.7 Margin Designators

SG2-2.7.1 Introduction. Margin designators are set in bold and comprise the last two digits of the year of publication enclosed in parentheses [e.g., **(21)**, **(22)**]. (See [SG2-4.5](#) for style rules covering margin designators used in Code cases.)

SG2-2.7.2 Positioning of Margin Designators

(a) *General.* Place margin designators² as follows:

(1) next to the designator of a revised paragraph (see also Note)

(2) next to the title of a revised table or figure

(3) next to the title of a chapter, part, etc., that has been revised in its entirety

EXCEPTION: If a breakdown within a paragraph runs for several pages, and the change does not occur on the same page as the paragraph’s boldface heading, place the margin designator next to the breakdown designator of the affected subparagraph.

(b) *Stress Tables.* In ASME BPVC, Section II-D stress tables, a margin designator may align with a row, general note, or referenced note. For example, if a seven-page table contains only one revision and that revision occurs in Note (1), the margin designator may be aligned with the first line of Note (1). Consult the Managing Editor for guidance on placement of margin designators in stress tables.

(c) *Footnotes and Endnotes.* Place the margin designator for a footnote or endnote revision next to the designator of the paragraph where the footnote or endnote is first referenced.

(d) *Deletions.* Best practice for documenting deletions and placing the related margin designators depends on context. The following are guidelines, not rigid principles. Consult the Managing Editor for guidance on placement of margin designators for deleted elements.

(1) *Deleted Paragraphs*

(-a) *First-Level Paragraphs.* If deleting a first-level paragraph, maintain the paragraph designator and title. Place the margin designator as you would for a paragraph revision. Insert the word “DELETED” on a new line after the designator and title.² See [Example SG2.23](#).

(-b) *Subordinate Paragraphs.* If deleting a second-level or other subordinate paragraph, delete the paragraph designator, title, and text. Place the margin designator at the paragraph one level above the deleted paragraph. Cite the designator for the deleted paragraph in the SOC *Change* description. For example, if deleting para. 1-2.3, place the margin designator at para. 1-2,

² Note to C&S Publishing staff: Specific XML tags or attributes apply. For XML instructions, see the Best Practices — Standards in the New XML.pdf available in T:\C&SPublishing\Editors\Reference Information.

and phrase the *Change* description as “Paragraph 1-2.3 deleted.”

(2) *Deleted Tables and Figures*

(-a) *Option 1.* If the table or figure deletion is one of many changes affecting the table’s or figure’s parent paragraph, delete the table or figure and its designator and title. Place the margin designator at the location of the parent paragraph (see [SG4-1](#) for definition of “parent paragraph”). Cite the designator for the deleted table or figure in the SOC *Change* description. For example, if Table 1-2.3-1 is being deleted, place the margin designator at para. 1-2.3, and phrase the *Change* description as “Table 1-2.3-1 deleted.”

(-b) *Option 2.* If the table or figure deletion is the only change associated with the table’s or figure’s parent paragraph, maintain the table or figure designator and title. Place the margin designator as you would for a table or figure revision. Insert the word “DELETED” on a new line after the designator and title.² See [Example SG2.24](#).

SG2-2.8 Running Heads

The C&S Publishing XML system automatically generates running heads. A running head comprises the full book designator and edition year (e.g., ASME PCC-1–2022). When reviewing proofs, confirm placement of the running heads as follows:

(a) *Front Matter.* Running heads do not appear in the front matter.

(b) *Main Text and Back Matter.* Beginning on page 1, the running head appears centered at the top of all pages in the main text and back matter.

EXAMPLES:

ASME BPVC.III.3-2021

ASME NQA-1–2022

EXCEPTION: No folio or running head appears on filler pages (i.e., Standard Series list pages and the ASME Services page) or the “Intentionally Left Blank” page following the filler pages.

SG2-2.9 References

SG2-2.9.1 Reference Tables. BPVC sections typically present references in a reference table rather than a list. Format a BPVC reference table as follows:

(a) Title and order the columns as follows: *Designator*, *Title*, and, if applicable, *Referenced Edition*. A reference table may include additional columns, but always set the *Designator* and *Title* columns as the first and second columns, respectively.

(b) Use bold subheadings within the table to group references by standard development organization (SDO).

(c) List the SDO groupings alphabetically by SDO name and the references within each SDO grouping alphanumerically by designator.

Some non-BPVC standards, e.g., ASME B31s and ASME NMs, use reference tables. Format the reference tables in non-BPVC standards as indicated in (a) through (c). Conversely, some BPVC Sections list references under a designated heading. See [SG2-2.9.2](#) for style rules for reference lists.

Reference tables appearing in the BPVC include the following:

Section	Table
I	A-360
III-Appendices	XXVI-I-100-1 and XXVI-A-110-1
III, Divisions 1 and 2	NCA-7100-1-1 and NCA-7100-2
III, Division 3	WA-7100-1 and WA-7100-2
III, Division 5	HAA-7100-1 and HAB-7100-1
IV	2-100
VIII-1	U-3
VIII-2	1.1
VIII-3	KG-141
X	1.1
XI, Division 1	IWA-1600-1
XI, Division 2	RIM-1.9-1
XII	TG-130
XIII	1.4-1

SG2-2.9.2 Reference Lists. Non-BPVC standards typically present references in a reference list. Format a reference list as follows:

(a) Title the reference list “References.”

(b) If referencing the latest edition of cited standards and specifications, include the following paragraph before the reference list and omit dates from the individual citations:

The following is a list of publications referenced in this Code [or “Standard”]. Unless otherwise specified, the latest edition shall apply.

If all cited documents include an edition year or publication year, you may omit an introductory paragraph and begin the list immediately after the “References” title. [See [WG1-3.3\(c\)](#) for general information on references.]

(c) Format the reference-list citations per the rules in [SG2-2.9.2.1](#) through [SG2-2.9.2.3](#), then list the references alphanumerically. Do not number the references.

SG2-2.9.2.1 Designated References (e.g., Standards, Specifications). Format alphanumerically designated references such as standards and specifications as follows. See [SG2-2.9.2.2](#) for formatting of BPVC citations.

(a) Cite the designator and, if applicable, the edition year followed by a period. Format the edition year as the work’s publisher does, e.g., preceded by a hyphen or en dash if the reference is an ASME standard, or a colon if the reference is an ISO standard. If the publisher

has no known format for edition date, enclose the date in parentheses.

(b) Cite the title, in roman, followed by a period. Set the title Uc/lc [see SG1-1(a)(3)].

EXCEPTION: Set titles of ISO standards in sentence case.

(c) Cite the publisher name, spelled out in full, but omit “Co.,” “Inc.,” “Ltd.,” etc. Omit the publisher location.

(d) End the citation with a period.

EXAMPLES:

With edition year

ASME PCC-1–2022. Bolted Flange Joint Assembly. The American Society of Mechanical Engineers.

Without edition year

ASME B16.1. Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250. The American Society of Mechanical Engineers.

NOTE: Include “The” only for ASME, not for other publishers.

SG2-2.9.2.2 ASME BPVC References. Format ASME BPVC citations as follows. See Table SG2-2.9.2.2-1 for examples of ASME BPVC citations.

(a) Begin the citation with “ASME Boiler and Pressure Vessel Code” followed by a comma and then the Section number.

(b) If referencing a specific edition, cite the edition year, enclosed in parentheses and followed by a period. If not citing a specific edition year, follow the Section number with a period.

(c) Cite the title of the Section.

(1) If the Section has no Part, Division, or Subsection, follow the Section title with a period.

(2) If the Section has a Part, Division, or Subsection, follow the Section title with an em dash. After the em dash, cite the Part, Division, or Subsection designator followed by a comma and then the Part, Division, or Subsection title. End the information with a period.

(3) If the Section has both a Division and a Subsection, use the style described in (2), but cite both the Division number and the Subsection designator, separated by a comma.

(d) Cite “The American Society of Mechanical Engineers” as publisher.

SG2-2.9.2.3 Authored and Other Undesignated References. Format authored and other undesignated references as follows. See Table SG2-2.9.2.2-1 for examples of the reference formats described in (a) through (f).

(a) *General Format*

(1) Cite the author’s last name followed by a comma and the author’s initials.

(-a) If the citation has two to ten authors, list each author using the last-name-comma-initials format, followed by a comma. Precede the last author name with “, and.”

(-b) If the citation has more than ten authors, list only the first ten authors followed by “, et al.”

(2) Cite the publication year enclosed in parentheses and followed by a period. If the publication date includes a month as well as a year, place the month (and day, if applicable) after the year, e.g., (1996, July).

(3) Cite the full book title and the volume and edition, if applicable, in the following format: Book Title, Vol. 1 (2nd ed.). End the book title information with a period.

(4) Format publisher information as detailed in SG2-2.9.2.1(c).

(5) End the citation with a period.

(b) *Organization as Author.* If the author is an organization rather than one or more individuals, place the organization name in the author position. If the organization is both the author and the publisher, do not repeat the publisher name after the book title. See also (c).

(c) *Title in Author Position.* If the reference has no author, place the title in the author position. You may also use this format as an alternative to (b). Consult the Managing Editor for guidance.

(d) *Book Chapters and Journal Articles.* If citing a book chapter or journal article, follow the same general format as for a book [see (a)] but with the following changes:

(1) Cite the chapter or article title, enclosed in quotes and followed by a period, before the book or journal title.

(2) If the citation is a book chapter, cite the page numbers, enclosed in parentheses, after the book title. If the book has a parenthetical edition number after the book title [see (a)], place the page numbers within the same parentheses as the edition number using the following format: (3rd ed., pp. 356–360). Precede a single page number with “p.” and a page range with “pp.” Use an en dash for page ranges.

(3) If the citation is a journal article, cite the journal title and the volume, issue, and page numbers using the following format: Journal Title, 1(2), 33–44. Note that not all journal article citations require a parenthetical issue number. Note also that unlike pages cited for book chapters, pages cited for journal articles are not preceded by “p.” or “pp.” Do not cite the journal publisher.

(e) *Conference Proceedings.* Cite conference proceedings in the same manner as book chapters [see (d)].

(f) *Inclusion of Report Numbers, Digital Object Identifiers,³ and Uniform Resource Locators*

(1) If a reference cited by author name includes a report number, cite the report number after the title, in parentheses, as you would an edition number [see (a)(3)].

³ Digital Object Identifier is a registered trademark.

Table SG2-2.9.2.2-1
Example Reference-List Citations for ASME BPVC and Authored or Undesignated Works

Citation Type or Format	Related Paragraph	Example
ASME BPVC		
Section, no Part, no edition year	SG2-2.9.2.2(c)(1)	ASME Boiler and Pressure Vessel Code, Section I. Rules for Construction of Power Boilers. The American Society of Mechanical Engineers.
Section with Part and edition year	SG2-2.9.2.2(c)(2)	ASME Boiler and Pressure Vessel Code, Section II (2021). Materials — Part A, Ferrous Material Specifications. The American Society of Mechanical Engineers.
Section with Division and Subsection, no edition year	SG2-2.9.2.2(c)(3)	ASME Boiler and Pressure Vessel Code, Section III. Rules for Construction of Nuclear Facility Components — Division 1, Subsection NB, Class 1 Components. The American Society of Mechanical Engineers.
Authored and Other Undesignated Works		
General format	SG2-2.9.2.3(a)	Law, A. M., and Kelton, W. D. (1991). Simulation Modeling and Analysis (2nd ed.). McGraw-Hill.
Organization as author	SG2-2.9.2.3(b)	ASCE Committee on Seismic Analysis (1983). Seismic Response of Buried Pipes and Structural Components. American Society of Civil Engineers.
Title in author position	SG2-2.9.2.3(c)	ASME Steam Tables (compact ed.) (2006). The American Society of Mechanical Engineers. Guide to the Expression of Uncertainty in Measurement (1993). International Organization for Standardization.
Book chapter	SG2-2.9.2.3(d)	Wagner, W. (2008). "IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam." International Steam Tables (pp. 7–150). Springer.
Journal article	SG2-2.9.2.3(d)	Haworth, D. C., El Tahry, S. H., and Huebler, M. S. (1993). "A Global Approach to Error Estimation and Physical Diagnostics in Multidimensional Computational Fluid Dynamics." International Journal for Numerical Methods in Fluids, 17(1), 75–97.
Conference proceedings	SG2-2.9.2.3(e)	Goodling, E. C. (1983). "Buried Piping — An Analysis Procedure Update." Proceedings of ASME Pressure Vessel and Piping Conference, Vol. 77 (pp. 225–237). The American Society of Mechanical Engineers.
Authored work with report number	SG2-2.9.2.3(f)(1)	Howard, A. K. (1977). Modulus of Soil Reaction (E'), Values for Buried Flexible Pipe (Report No. REC-ERC-77-1). U.S. Department of the Interior, Bureau of Reclamation.
Citation with DOI	SG2-2.9.2.3(f)(2)	Gordon, C. G. (1999). "Generic Vibration Criteria for Vibration-Sensitive Equipment." Proceedings of SPIE, Optomechanical Engineering and Vibration Control, 3786, 22–33. https://doi.org/10.1117/12.363802

(2) If a listing includes a Digital Object Identifier (DOI) or a uniform resource locator (URL), include the DOI or URL at the end of the listing, following the end period. No punctuation follows the DOI or URL.

NOTES:

- (1) The C&S Publishing reference-list style is a modified version of the American Psychological Association's author-date reference style. See <https://apastyle.apa.org/style-grammar-guidelines/references> for additional guidance. Note that the ASME style uses roman type rather than italics for journal and book titles and places a period between the author and the parenthetical year only if needed for the author's initials.
- (2) The committee is responsible for submitting a complete, accurate reference list with each manuscript. The C&S Publishing editor copyedits the reference list for proper ASME style but is not responsible for fact-checking the publication details of the references.

SG2-2.9.3 In-Text Citation of References. In-text citations must mirror reference-list citations to ensure that users can easily locate in the reference list the citations they see in text. If the text cites a work by designator or other alphanumerical identifier (e.g., a report number), then list the work by the designator or identifier in the reference list. If the text cites a work by author name, then list the work by author name in the reference list. See [paras. SG2-2.9.3.1 through SG2-2.9.3.3](#) for additional style rules.

SG2-2.9.3.1 In-Text Citations of Non-BPVC Standards and Authored Works

(a) If referencing standards other than the ASME BPVC, cite only the designator in the text (e.g., ASME B16.22, ASTM A740) — do not include the title of the standard. If referencing a specific element of the work, cite the element designator after the standard designator (e.g., "See ASME PCC-1, Nonmandatory Appendix H"). See [SG2-2.9.3.3](#) for style rules for cross-references within a standard.

(b) If referencing a work listed by author in the reference list, cite the author's last name followed by a comma and the publication year. Enclose the citation in parentheses.

EXAMPLES:

one author:	(Gordon, 1991)
two to three authors:	(Law and Kelton, 1991) (Dickens, Scrooge, and Marley, 1843)
four or more authors:	(Smith et al., 2013)

If the citation is part of the sentence, omit the comma before the publication year and enclose only the year in parentheses.

EXAMPLE:

According to Shakespeare (1599), the fault lies not in our stars but in ourselves.

SG2-2.9.3.2 In-Text Citations of ASME BPVC

(a) *Within BPVC Sections*

(1) If referencing a paragraph, figure, table, appendix, or any other element **within** the BPVC Section, cite the designator of the element only. The following examples, taken from Section XII, reference elements within Section XII:

EXAMPLES:

For further information, see TD-410.

See Article TF-7.

Mandatory Appendix IV provides further explanation.

(2) If referencing a paragraph, figure, table, appendix, or any other element in **another** BPVC Section, cite the Section followed by a comma and then the designator of the element.

EXAMPLES:

These symbols are defined in Section III Appendices, Mandatory Appendix XI, XI-3130.

See Section VIII, Division 1, Mandatory Appendix 24, 24-1.

For further explanation, see the Nuclear Code Cases, N-253-14.

See Section II, Part D, Subpart 1, Tables 2A and 2B.

(b) *In Non-BPVC Standards*

(1) If referencing the BPVC in its entirety, format the first in-text citation as follows: "the ASME Boiler and Pressure Vessel Code (BPVC)." In subsequent citations, cite the abbreviation only: "ASME BPVC."

(2) If referencing a specific BPVC Section, format the in-text citation as in the following example: "ASME BPVC, Section VIII, Division 1, Part UG, UG-85." If the citation is the first in-text citation of the ASME BPVC, spell out "BPVC" as described in [\(1\)](#).

SG2-2.9.3.3 Cross-References Within a Standard

(a) *Cross-References to Paragraphs*

(1) In BPVC Sections, cite the paragraph designator. See [SG2-2.9.3.2\(a\)](#) for additional details.

(2) In non-BPVC standards, cite the paragraph designator preceded by the abbreviation "para." Spell out "Paragraph" if the cross-reference begins the sentence. If cross-referencing multiple paragraphs, apply the following style rules:

(-a) If the cross-references are connected by "or," repeat the word "para." before each paragraph designator.

(-b) If the cross-references are connected by "and," use the abbreviation "paras." before the first paragraph designator. Spell out "Paragraphs" if the cross-references begin the sentence.

(-c) If cross-referencing three or more consecutive paragraphs, cite the first and last paragraphs in the range, connected by "through."

EXAMPLES:

The requirements of para. 2-3.2 or para. 3-3.2 apply.

See paras. 2-3.2 and 2-3.3.

Paragraphs 2-3.2 through 2-3.4 describe the design requirements.

(b) Cross-References to Breakdown Items. The cross-references to a breakdown item (i.e., a subparagraph) follow the hierarchy of the designators under which the breakdown item appears. Format cross-references to breakdown subparagraphs as illustrated by the following examples for “para. 2.1(a)(1)(-a)”:

If cross-referencing para. 2.1(a)(1)(-a) in	Format the cross-reference as
para. 2.1(a)(1)	(-a)
para. 2.1(a)(1)(-b) or a subsequent third-level subparagraph within para. 2.1(a)(1)	(-a)
para. 2.1(a)(2) or subsequent subparagraph within para. 2.1(a)	(1)(-a)
para. 2.1(b) or subsequent subparagraph within para. 2.1	(a)(1)(-a)
any paragraph outside of para. 2.1	para. 2.1(a)(1)(-a)

(c) Cross-References to Figures and Tables

(1) Cite the figure or table designator preceded by “Figure” or “Table,” respectively. See also [SG5-6\(b\)\(2\)](#) for treatment of cross-references to multi-illustration figures.

(2) If cross-referencing multiple figures or tables, treat the cross-references in the same manner as for cross-references to multiple paragraphs [see [\(a\)\(2\)\(-a\)](#) through [\(a\)\(2\)\(-c\)](#)].

(3) If cross-referencing complementary U.S. Customary and SI figures or tables, cite the designator of the primary-unit figure or table first followed by the designator of the secondary-unit figure or table in parentheses. Repeat the label “Figure” or “Table” within the parentheses.

EXAMPLES:

Washers shall conform to the dimensions in Table M-2.6.1-1 or Table M-2.6.1-2.

See Figures 2-3.2-1 and 2-3.3-1.

See Figures 2-3.2-1 through 2-3.2-4.

See Table 2-3.2-1 (Table 2-3.2-1M).

See Tables 2-3.2-1 and 2-3.2-2 (Tables 2-3.2-1M and 2-3.2-2M).

(d) Cross-References to Equations. Formatting of equation cross-references depends on the manner in which the equations are numbered (see [SG3-3.4.2](#)).

(1) If the equation is numbered using the paragraph-based designation scheme [see [SG3-3.4.2\(b\)](#)], cite the equation number, enclosed in parentheses, preceded by “eq.” Spell out “Equation” if the cross-reference begins the sentence.

(2) If the equation is numbered using a method other than the paragraph-based designation scheme [see [SG3-3.4.2\(a\)](#)], format the cross-reference as follows:

(-a) If cross-referencing the equation within the paragraph in which the equation displays, format the cross-reference as described in [\(1\)](#).

(-b) If cross-referencing the equation outside of the paragraph in which the equation displays, cite the equation’s paragraph as well as the equation number. The order of information will vary depending on context. The following two examples present general formats. Consult the Managing Editor for additional guidance.

EXAMPLES:

See para. 2.3, eq. (2).

Determine P_c using eq. (2) of para. 2.3.

(3) If cross-referencing multiple equations, treat the cross-references in the same manner as for cross-references to multiple paragraphs [see [\(a\)\(2\)\(-a\)](#) through [\(a\)\(2\)\(-c\)](#)].

EXAMPLES:

Use either eq. (2-3-1) or eq. (2-3-2).

Using eqs. (17) and (18), determine the maximum allowable leak rate.

Equations (4) through (6) yield the following results.

(e) Cross-References to Appendices

(1) If referring to an appendix **within** that same appendix, use the phrase “this Appendix” (e.g., “The capabilities of pressure-containing equipment are outside the scope of this Appendix”).

(2) If cross-referencing an appendix paragraph, figure, table, or other element from **within** that same appendix, cite only the element designator (e.g., “See para. II-2.1”).

(3) If cross-referencing an appendix **outside** of the referenced appendix, cite the full appendix designator (e.g., “See Mandatory Appendix I”; “See Nonmandatory Appendix B”). If cross-referencing a specific appendix paragraph, figure, table, or other element, cite the full appendix designator followed by a comma and then the element designator (e.g., “See Mandatory Appendix II, para. II-2.1”).

NOTE: If repetition of the appendix designator in successive cross-references detracts from readability, consult the Managing Editor for guidance.

(f) Parenthetical Cross-References. If providing a cross-reference as a parenthetical aside, precede the cross-reference with “see,” e.g., “(see para. 1-2.3 and Table 1-2.3-1).”

(g) Treatment of Cross-Reference Links. ASME standards link cross-references. Include both the label (e.g., para., eq., Table, Figure, Note) and the designator within the link. If a cross-reference comprises two elements, e.g., a paragraph designator and an equation

number, link the entire expression to the element to which the text is directing the user. For example, the expression “para. 2.3, eq. (2)” would link to the equation only, not to the paragraph and the equation.

SG2-2.10 Use of Copyrighted Material

SG2-2.10.1 Securing Permissions. Contact the ASME manager of intellectual property rights to secure permissions. Provide the following information for the material being republished or adapted by ASME:

- (a) author or name of organization that published the original work in which the material appeared
- (b) title, including designator, of the original work
- (c) date of publication of the original work
- (d) page numbers on which the material appeared in the original work
- (e) identifying information such as the figure number or table title
- (f) planned use, i.e., whether the material is being republished or adapted

NOTES:

- (1) U.S. copyright law allows for “fair use”—certain instances in which material may be reprinted without obtaining permission from the copyright owner. These instances include criticism, comment, news reporting, teaching, scholarship, and research. Do not assume that use of material in a standard is fair use. When in doubt, request permission.
- (2) Regardless of whether use of others’ material requires permission, you must acknowledge the source of republished or adapted material. See [SG2-2.10.2](#) for placement and wording of credit lines.

SG2-2.10.2 Credit Lines

(a) *Placement of Credit Lines.* If republishing text, place the credit line in a footnote or endnote. If republishing a figure or table, place the credit line in a general note (see [SG4-2.6.2](#)).

(b) Wording of Credit Lines

(1) If the copyright owner specifies particular wording for the copyright permission statement, use the specified wording.

(2) If the copyright owner does not specify particular wording for the copyright permission statement, use one of the following credit lines:

(-a) If ASME has paid the copyright owner for use of the material, use “<<Element>> from <<Source>>.”

(-b) If the copyright owner has granted ASME use of the material free of charge, use “<<Element>> courtesy of <<Source>>.”

(-c) If ASME is adapting rather than republishing the material, use “<<Element>> adapted from <<Source>>.”

EXAMPLES:

Data from NFPA-99, Standards for Health Care Facilities, National Fire Protection Association, Quincy, MA.

Figure courtesy of Jones, Inc.

Table adapted from Shapiro and Wilk (1965), Tables A-1 and A-2, by permission of Oxford University Press.

SG2-3 MANDATORY AND NONMANDATORY APPENDICES

(a) Designation of Appendices

(1) Designate each mandatory appendix with a roman numeral (e.g., Mandatory Appendix I) and provide a title. Set the title all uppercase.

(2) Designate each nonmandatory appendix with an uppercase letter (e.g., Nonmandatory Appendix A), but skip letters I, V, and X, which are used for mandatory appendices. Provide a title for each nonmandatory appendix. Set the title all uppercase.

(b) Designation of Appendix Paragraphs, Tables, Figures, and Equations

(1) Designate and title appendix paragraphs in the same manner as for paragraphs in a multichapter standard (see [SG2-2.1.2](#)). Begin each designator with the appendix numeral or letter followed by a hyphen, e.g. I-1, A-1.1.

(2) Designate appendix tables and figures as indicated in [SG4-2.2](#) and [SG5-3](#), respectively.

(3) Number appendix equations as indicated in [SG3-3.4](#).

(c) *Running Heads in Appendices.* See [SG2-2.8](#).

(d) *Cross-References to Appendices.* See [SG2-2.9.3.3\(e\)](#).

(e) *Footnotes in Appendices.* Within each appendix, number footnotes consecutively beginning with “1.” See [SG2-2.5.2](#).

SG2-4 CASES

See [WG2-3](#) for a description of cases. The information in [SG2-4.1](#) through [SG2-4.5](#) applies to Code cases, i.e., cases for BPVC Sections. Contact the applicable ASME staff secretary for guidance on cases for non-BPVC standards.

C&S Publishing staff can access the Updated Code Case Procedures document⁴ for detailed information on downloading Code case records, numbering Code cases, compiling Code case SOC, and styling Code cases.

SG2-4.1 Newly Adopted Cases

(a) Begin each case on its own page, with the following introductory information:

(1) the board approval date

(2) the following statement, in italic: *Code Cases will remain available for use until annulled by the applicable Standards Committee.*

(3) the case number

(4) the subject of the case

⁴ The Updated Code Case Procedures document is available in T:\C&SPublishing\Editors\Reference information\Code Case procedures.

(5) the applicable BPVC Section or Sections

(b) Follow the introductory information with the text of the case. Preface the inquiry portion of the text with the italicized title *Inquiry* followed by a colon and then the text of the inquiry. Format the reply portion of the text in the same way as the inquiry, but with the title *Reply*. Apply the style rules of [Subparts SG1](#) and [SG2](#) to the text of both the inquiry and the reply. Designate paragraphs in the same manner as in the applicable BPVC Section or per the style for nonchapter standards (see [SG2-2.1.1](#)). Designate figures and tables as follows:

(1) If the case is 20 or fewer pages, designate tables and figures consecutively starting at “1” (i.e., Table 1, Table 2, Figure 1, Figure 2, etc.).

(2) If the case is longer than 20 pages, designate tables and figures per the rules in [SG4-2.2](#) and [SG5-3\(b\)](#), respectively.

Regardless of designation style, cite in the text of either the inquiry or the reply all tables and figures included in the reply.

See [Example SG2.25](#).

(c) List each new case and its Board approval date in the numeric index. List the title and number of each new case in the subject index. If the case is a Section XI case, update the applicability index. If the case contains reference to ASME, ASTM, or international specifications, list the specification and case number in the material specifications index.

SG2-4.2 Annulments

If publishing the announcement of a pending annulment, see the Updated Code Case Procedures document⁴ for instructions. If publishing an annulment, apply the following rules:

(a) Present each annulled case on its own page. Include the following information:

(1) the case number, title, and applicable BPVC section

(2) the word “ANNULLED”

(3) the annulment date

(4) the committee-provided reason for the annulment, using one of the following phrases:

(-a) “No longer needed.”

(-b) “Requirement incorporated into Section <<Section number>>.”

(b) Maintain each annulled case in the numeric and subject indices until the next edition of the BPVC. In the next edition, delete the annulled-case page from the book and the related entries from the numeric, subject, and material specifications indices.

SG2-4.3 Revised Cases

Treat a revised case in the same manner as a new case (see [SG2-4.1](#)) but with the following changes:

(a) Number a revised case using the original case number followed by a hyphen and a numerical suffix (e.g., case 1467 becomes 1467-1; case 1862-1 becomes 1862-2).

(b) Update the Board approval date to the date of approval of the revision.

(c) Update the case number in the numeric index and the title, if revised, in the subject index. Add to or delete from the material specification index any material specification added to or deleted from the revised case.

SG2-4.4 Reinstatements

Treat a reinstated case in the same manner as a revised case (see [SG2-4.3](#)) but with the following changes:

(a) Number a reinstated case based on the case number of the annulled case. For example, if the annulled case was 1862, the reinstated case is 1862-1; if the annulled case was 1862-2, the reinstated case is 1862-3.

(b) If the reinstated case does not include any changes to the annulled case, include a footnote that reads, “There is no change to this reinstated Case.” Place the footnote reference after the case title.

(c) In the numeric index, add the letter prefix “R” to the updated approval date (e.g., R9-3-2008).

SG2-4.5 Errata

Use the margin designator (**E**) to indicate errata corrections in Code cases. Place the margin designator next to the title of the paragraph, figure, or table in which the correction has been made.

SG2-5 ERRATA TO STANDARDS

See [WG2-4](#) for a description of errata and for C&S Publishing’s criteria for printing errata.

Format an errata sheet as follows:

(a) *Errata to Non-BPVC Standards*

(1) Title the errata sheet “Errata to ASME <<standard designator and edition year>>.” Follow the errata title with the title of the standard.

(2) State the purpose of the errata sheet.

(3) List the errata in an SOC-style table comprising three columns, *Page*, *Location*, and *Change*. See [SG2-1.4\(b\)\(3\)](#) for guidance on writing *Change* descriptions for errata.

(4) Include the ASME address, date of issuance (month and year only), bar code, and book number at the bottom of the page.

(5) Provide the revised text, figure, or table beneath the SOC-style table or on subsequent pages.

See [Example SG2.26](#).

(b) *Errata to BPVC*. Format an errata sheet for a BPVC Section in the same manner as for a non-BPVC standard, but title the sheet “SPECIAL ERRATA to ASME Boiler and Pressure Vessel Code.” See [Example SG2.27](#).

SUBPART SG3

NUMBERS, EQUATIONS, AND TECHNICAL TERMINOLOGY

SG3-1 GLOSSARY OF MATHEMATICAL TERMS USED IN THIS SUBPART

coefficient: a number that precedes a variable to form a product.

display math: a mathematical expression that is set apart from text. Also called *display equation*.

equation: a mathematical expression in which two values are equal as indicated by “=” or unequal as indicated by operational signs such as “<” or “>” (e.g., $|z| = 2bz$; $k_i/r > C_c$).

mathematical expression:

(a) two or more variables with or without a coefficient that form a product (e.g., xy , $4ab$, $7xy$).

(b) any combination of numbers and variables connected by one or more operational signs.

Mathematical expressions may be display math or may be included within the text.

math symbols: a collective term referring to numbers, variables, and operational signs.

operational sign: a symbol used to indicate a mathematical operation or relation.

variable: an indefinite quantity expressed by a letter or symbol.

SG3-2 NUMERALS VS. WORDS

SG3-2.1 General Principles

(a) Use numerals for all numbers in mathematical expressions. See also (c).

(b) Apply the following rules to numbers that are not part of a mathematical expression. See also (c).

(1) Use numerals for whole numbers greater than 10.

(2) Spell out whole numbers 0 through 10 except in the following contexts:

(-a) The number is accompanied by a unit of measure (e.g., 2 in., 4 mm, 5%) or expresses a ratio [see SG3-2.3(c)].

(-b) The number expresses a factor of safety, a multiplier, or magnification.

EXAMPLES:

The factor of safety for overhead beams shall be not more than 5 for steel and 6 for timber.

$2\frac{3}{4}$ times the radius

3 times larger than the diameter

10X magnification

NOTE: Use uppercase X, not the multiplication sign, to indicate magnification.

(-c) The number is used in combination with other numerical phrases involving numbers greater than 10.

EXAMPLE:

There were 10 screws, 16 bolts, and 87 nuts.

(3) Within a paragraph, treat numbers that relate to the same topic in the same way. If one item takes a numeral per (1), use numerals for all like items within the paragraph.

EXAMPLE:

The 13 engineers built three-layered pressure vessels. A team of 10 worked on the first two layers while the remaining 3 constructed the third.

(c) Spell out numbers that begin a sentence even if the rules in (a) and (b) would dictate use of a numeral. Apply the rules of (a) and (b) to any subsequent numbers in the sentence.

EXAMPLE:

Seventy-five percent of the members attended the meeting, but only 35% voted.

SG3-2.2 Fractions and Mixed Numbers

(a) In mathematical expressions and for values given with a unit of measure, set fractions as case fractions (e.g., $\frac{3}{4}$, not $3/4$) except in the following contexts:

(1) The fraction is an exponent. Set exponent fractions on the baseline [e.g., $(x - y)^{1/2}$].

(2) The fraction comprises a numeral and a variable. Set such fractions on the baseline (e.g., $2/t$, not $\frac{2}{t}$).

(b) Outside of the contexts described in (a), spell out and hyphenate simple fractions (e.g., one-half, two-thirds, three-fourths, nine-fifths), but set complex fractions such as $\frac{3}{1,000}$ or $\frac{5}{233}$ as case fractions.

(c) Use numerals for mixed numbers, with no space or dash between the integer and the fraction (e.g., $4\frac{1}{2}$).

SG3-2.3 Decimals, Percents, and Ratios

(a) Decimals

(1) Use numerals for all decimal fractions.

(2) Include a 0 before the decimal point in decimal fractions less than 1 (e.g., 0.6, not .6).

(b) Percents

(1) Use numerals and the percent symbol (%) for specific percentage values (e.g., 100%).

(2) Spell out the word “percent” when no numerical value is given (e.g., “a small percent of the test plants”).

(c) Ratios. Use numerals for ratios (e.g., “The taper shall be at least 1:3”).

SG3-3 EQUATIONS AND OTHER MATHEMATICAL EXPRESSIONS

SG3-3.1 Display vs. In-Text Math

(a) *General Principles.* Equations may be set as display math or included in text, depending on complexity and usage. The following are guidelines, not rigid principles. Consult the Managing Editor with questions regarding setting an equation as display math vs. in-text math. See [SG3-3.4](#) for style rules on numbering display equations.

(1) Set long or complex equations, such as those with radicals, integrals, or double superscripts and subscripts, as display math.

(2) Set short or simple equations as either display math or in-text math based on context and usage. If the equation comprises only keyboard characters (e.g., $L = 2.5T_b + t_e$), can be easily understood as part of the sentence, and is not cross-referenced, include the equation within the text of the paragraph. If the equation is cross-referenced in text, set it as display math and number it to facilitate the cross-referencing.

(b) *Parallel Equations.* If the standard presents values in both U.S. Customary and SI units, provide parallel display equations. Place the equation for the primary units first. Label the equations as shown in the following example:

EXAMPLE:

(U.S. Customary Units)

$$G = 1.7 \times 10^6 C_d LA$$

(SI Units)

$$G = 3.6 \times 10^6 C_d LA$$

SG3-3.2 Horizontal Spacing

(a) *Coefficients and Variables.* Close up mathematical expressions comprising a coefficient and a variable (e.g., $4sy$, not $4 sy$).

(b) *Operational Signs.* Insert a space before and after an operational sign (+, −, =, ×) unless the sign indicates measure (e.g., $a^2 + b^2 = c^2$, but -15% , ± 3).

NOTE: Do not use a middle dot (·) or an asterisk (*) to indicate multiplication. Use a multiplication sign or close up the expression as indicated in [\(a\)](#), e.g., $a^2 b^2$, not $a^2 \cdot b^2$.

(c) *Degree Sign.* In expressions of temperature, close up the degree sign to both the temperature value and the scale abbreviation (e.g., 100°F , 32°C , 491.67°R). Note that temperatures measured in the kelvin scale omit the degree sign (e.g., 2 000 K).

(d) *Percent Sign.* Close up a percent sign to its value (e.g., 90%).

(e) *Units of Measure.* Separate a quantity from a unit of measure by one space (e.g., 2 in., 4 mm). See also [SG1-3.2\(a\)\(2\)](#) for style rules regarding hyphenation of quantities and units of measure.

(f) *Functions and Limits.* Leave no space between a function or limit and the opening parenthesis that follows it [e.g., $\max(x, y)$]. See also [SG1-2.1\(f\)](#) and [SG3-3.3\(b\)](#) for additional style rules regarding abbreviation of “maximum” and “minimum.”

SG3-3.3 Punctuation

(a) Of Display Math

(1) Omit a period immediately after display math even if the equation completes the sentence begun in the lead-in to the equation.

(2) If the text that leads into display math is a fragment, end the fragment with no punctuation.

(3) If the text that leads into display math is a complete sentence, end the sentence with a colon.

EXAMPLES:

Lead-In Fragment

For a rectangular duct, the surface area is

$$A = \frac{\ell_d}{6}(h + b)$$

Lead-In Sentence

To meet this criterion, first calculate the flow rate, Q_1 :

$$\begin{aligned} Q_1 &= 50 \text{ ft}^3/\text{min} \times 25 \text{ ft} \\ &= 1.250 \text{ ft}^3/\text{min} \end{aligned}$$

(b) *Of “Min.” and “Max.”* Omit the period from abbreviations “min” and “max” when the terms are used as subscripts (e.g., $T_{\min}$) or precede a set of elements [e.g., $\max(x, y)$]. See also [SG1-2.1\(f\)](#).

(c) *Of Multiple Subscripts.* Separate with a comma multiple subscripts to the same term (e.g., $F_{t,\min}$). Leave no space after the comma.

(d) *Of Parenthetical Expressions.* Set off parenthetical information in equations following the same order of distinction as used in text: parentheses, then brackets enclosing parentheses, then braces enclosing brackets.

EXAMPLES:

$\{a[b + c(d - e)]\}$

$\pm 0.1 \text{ in. wg } [0.025 \text{ kPa (gauge)}]$

(e) *Of U.S. Customary vs. SI Units*

(1) Use commas in U.S. Customary values greater than 999 (e.g., 4,000°F; 12,000 ft; 120,000 lb).

(2) Use hair spaces in SI values greater than 999 (e.g., 1 000°C, 22 000 m, 220 000 kg).

SG3-3.4 Numbering Equations

SG3-3.4.1 General Principles

(a) Number each display equation cross-referenced in text. You may number or leave unnumbered any display equation not cross-referenced in text.

(b) Enclose equation numbers in parentheses.

(c) Format cross-references to equations per SG2-2.9.3.3(d).

SG3-3.4.2 Format of Equation Numbers. The format of equation numbers varies across ASME's many standards. The following are therefore guidelines, not rigid principles. Consult the Managing Editor with questions regarding numbering of equations.

(a) *Existing Standards.* If revising an existing standard, review the existing equation numbers for guidance on numbering any new equations. If the existing numbering scheme is consistent and logical, number newly added equations in the same manner as the existing equations. If the existing scheme is inconsistent or illogical, consult the Managing Editor for further guidance. If renumbering *all* equations in an existing standard or adding equations for the first time, use the paragraph-based numbering scheme described in (b).

(b) *New Standards.* If writing a new standard, number equations based on the "primary" section, i.e., the first-level paragraph, in which the equations display. Use the applicable first-level paragraph designator followed by a hyphen and then a numeral, starting with "-1" and continuing chronologically. Begin the hyphenated numerals at "-1" in each new first-level-paragraph section. The following examples illustrate the paragraph-based numbering scheme:

EXAMPLES:

Nonchapter Standards. Equations displaying in paras. 7, 7.1, and 7.2.1 would be numbered (7-1), (7-2), and (7-3), respectively, since "7" is the first-level designator that applies to all three paragraphs. Equations displaying in paras. 8, 8.1, and 8.2.1 would be

numbered (8-1), (8-2), and (8-3), respectively, since "8" is the first-level designator that applies to all three paragraphs.

Multichapter Standards. Equations displaying in paras. 7-1, 7-1.1, and 7-1.3.2 would be numbered (7-1-1), (7-1-2), and (7-1-3), respectively, since "7-1" is the first-level designator that applies to all three paragraphs. Equations displaying in paras. 8-2, 8-2.1, and 8-2.2.1 would be numbered (8-2-1), (8-2-2), and (8-2-3), respectively, since "8-2" is the first-level designator that applies to all three paragraphs.

Appendices. Equations displaying in paras. A-1, A-1.1, and A-1.3.2 would be numbered (A-1-1), (A-1-2), and (A-1-3), respectively, since "A-1" is the first-level designator that applies to all three paragraphs. Equations displaying in paras. A-2, A-2.1, and A-2.2.1 would be numbered (A-2-1), (A-2-2), and (A-2-3), respectively, since "A-2" is the first-level designator that applies to all three paragraphs.

SG3-3.4.3 Placement of Equation Numbers.

The C&S Publishing XML system places the equation number flush right of the display equation. Vertical positioning varies depending on the length of the equation or the number of equations displayed sequentially. See Examples SG3.1 and SG3.2.

SG3-3.5 Breaking Equations

(a) Break an in-text or display equation just before an operational sign such as "+", "-", or "=".

(b) Align run-over lines of a display equation as follows:

(1) If the run-over line begins with an equal sign (=), align on the equal sign of the first line. See Example SG3.3.

(2) If the run-over line begins with an operational sign other than an equal sign or with a numeral or letter, align on the first character after the equal sign of the first line. Example SG3.4.

SG3-4 TYPE STYLES FOR MATH SYMBOLS AND OTHER MATH-RELATED TEXT

SG3-4.1 Italics

Italicize the following:

(a) variables, including sub- and superscripts that are variables (e.g., E_a , t_s) or single-letter abbreviations (e.g., q_r , where r stands for "reference"). See also SG3-4.2(d).

(b) e for "exponent" (but not the fuller abbreviation "exp"), d for "derivative," and f for "function."

(c) Greek letters that represent variables. Do not italicize the following Greek letters:

(1) uppercase delta, Δ , used to indicate change

(2) lowercase mu, μ , used in abbreviated units of measure to indicate the prefix "micro"

(3) lowercase pi, π , which represents a mathematical constant

(4) uppercase sigma, Σ , used as a summation sign

EXAMPLES:

$$q_m = 2\rho \times \Delta P$$

$$2x = 40 \mu\text{m}$$

NOTE: Avoid using the Greek letter Δ as a variable. If Δ is used as a variable, italicize it (e.g., Δ_t).

See [SG3-7](#) for style rules on italicizing genus and species names.

SG3-4.2 Roman Type

Set the following in roman type:

(a) numerals, units of measure, and the following mathematical abbreviations:

Abbreviation	Definition
cos	cosine
cosh	hyperbolic cosine
cot	cotangent
coth	hyperbolic cotangent
csc	cosecant
e	base of natural logarithm
ln	natural logarithm
log	logarithm
max [Note (1)]	maximum
min [Note (1)]	minimum
sec	secant
sech	hyperbolic secant
sin	sine
sinh	hyperbolic sine
tan	tangent
tanh	hyperbolic tangent
tr	trace
var	variance

NOTE: (1) See also [SG1-2.1\(f\)](#) and [SG3-3.3\(b\)](#).

(b) letters that represent mathematical constants

(c) letters used to describe geometric figures (e.g., line A, point B)

(d) sub- or superscripts comprising whole words or abbreviations of two or more letters [e.g., LHV_{avg} , $T_{cooling}$, H_{min} , W_{pf} (where “pf” stands for “primary fuel”), m_{HTF} (where “HTF” stands for “heat transfer fluid”)]

(e) acronyms or initialisms used in equations and defined in nomenclature (see [Example SG3.5](#))

(f) the slash between two variables or other italicized mathematical expressions

SG3-5 NOMENCLATURE

A standard must define all variables used within text, equations, figures, and tables [see also [SG1-2.3\(b\)](#), [SG4-2.6.1](#), and [SG5-7.1](#)]. A nomenclature may be a comprehensive listing defining variables for the entire standard, or it may be specific to a single equation, series of equa-

tions, or section of the standard. Apply the following rules to nomenclature:

(a) If defining a nomenclature for an individual equation, place the nomenclature after the equation, preceded by the word “where.” Set “where” flush left on its own line with no punctuation. Begin the nomenclature on the next line. See [Example SG3.5](#).

(b) If defining nomenclature for a series of equations within the same designated paragraph, set the nomenclature after the last equation in the series, preceded by “where” as described in (a). See [Example SG3.6](#).

(c) If defining a nomenclature for an entire standard or section of the standard, provide a title (e.g., “Nomenclature”) or a sentence or paragraph to introduce the listing. See [Example SG3.7](#).

(d) Order both comprehensive and individual nomenclatures alphanumerically as follows:

- letter
- letter + numeric subscript without minus sign
- letter + numeric subscript with minus sign
- letter + numeric superscript without minus sign
- letter + numeric superscript with minus sign
- letter + one or more prime symbols
- letter + alpha subscript without minus sign
- letter + alpha subscript with minus sign
- letter + alpha superscript without minus sign
- letter + alpha superscript with minus sign
- Greek letters, ordered as letters above

If there are uppercase and lowercase versions of the same variable (e.g., A and a), place the uppercase variable first.

EXAMPLE:

A
 a
 A_1
 a_1
 A_{-1}
 a_{-1}
 A_1^1
 a_1^1
 A^{-1}
 a^{-1}
 A'
 a'
 A''
 a''
 A'''
 a'''
 A_a
 a_a
 A_{-a}
 a_{-a}
 A^a
 a^a
 A^{-a}
 a^{-a}
 α
 α_1
 α_{-1}

 α^1
 α^{-1}
 α_a
 α_{-a}
 α^a
 α^{-a}

(e) Follow each variable with “=” and then the definition, formatted as follows:

(1) Omit the article (“a,” “an,” or “the”) at the beginning of the definition and begin the definition with a lower-case letter.

(2) Omit end punctuation unless the definition includes a complete sentence. Include the unit of measure, abbreviated and preceded by a comma, at the end of the definition.

(3) If the variable has more than one definition or a definition and an equation, begin each definition or equation on its own line, preceded by “=.” Do not repeat the variable. See [Example SG3.8](#).

SG3-6 RADIOLABELED COMPOUNDS¹

Specify the isotope of an element by a mass number written as a left superscript to the element symbol.

EXAMPLES:

 ^{13}C
 ^{238}U
 ^{242}Pu

The isotope name or symbol is pronounced first, followed by the number. For example, “ ^{238}U ” is pronounced “u two thirty-eight.” Therefore, use the indefinite article (“a” or “an”) that accommodates the pronunciation of the element name, not of the number.

EXAMPLES:

a ^{238}U isotope

an ^{58}Fe isotope

SG3-7 GENUS AND SPECIES

(a) On the first mention, spell out both the genus and species names. Capitalize the genus name, and lowercase the species name. Italicize the entire term.

EXAMPLES:

Styrax californica

Esox lucius

(b) After the first mention, abbreviate the genus name: use the first letter of the genus followed by a period.

EXAMPLES:

S. californica

E. lucius

EXCEPTION: If an abbreviation would create ambiguity (e.g., *Escherichia coli* and *Entamoeba coli* are named in the same document), spell out the genus name for clarity.

¹ Adapted from Coghill, A. M., and Garson, L. R. (Eds.) (2006). The ACS Style Guide: Effective Communication of Scientific Information. Oxford University Press.

SUBPART SG4 TABLES

SG4-1 GLOSSARY OF TERMS USED IN THIS SUBPART

designated table: a table comprising a designator, title, column headings, and columns and rows of data.

in-text table: a table comprising column headings and a few columns and rows of data, set within or immediately after the paragraph that introduces the table data.

parent paragraph: the paragraph that introduces the data in or topic of a designated table or figure. The designator of the table or figure is based on the designator of the parent paragraph.

snaked table: a designated or in-text table in which the columns break and then continue from the top of the table.

spread table: a designated table that extends, or “spreads,” across two or more facing pages to accommodate all the columns of data.

SG4-2 DESIGNATED TABLES

SG4-2.1 General Principles

Most tables in ASME standards are designated tables. ASME standards designate, or number, a table based on the table’s parent paragraph. This paragraph-based numbering scheme facilitates page layout, provides unique designators for cross-referencing, and enables the user to locate the text associated with the table. You must cite each designated table at least once in text to establish the table’s parent paragraph. The parent paragraph is usually but not always the paragraph in which the table is first cited.

SG4-2.2 Table Designators

Format table designators as follows:

(a) If the parent paragraph introduces only one table, designate the table using the paragraph designator followed by the numerical suffix “-1.” For example, if this paragraph introduced a table, the table would be designated Table SG4-2.2-1.

(b) If the parent paragraph introduces more than one table, designate the tables using the paragraph designator and successive numerical suffixes, starting with “-1” for the first table cited and continuing chronologically for each subsequent table. [See SG5-3(b)(3) for style rules

on numbering tables and figures introduced in the same parent paragraph.]

EXAMPLE:

P-5 LEAKAGE PROBLEMS AND POTENTIAL SOLUTIONS

Tables P-5-1 and P-5-2 provide recommendations for diagnosing and resolving leaks.

(c) If the standard includes complementary U.S. Customary and SI tables, format the table designators as follows:

(1) Designate the table of primary units as described in (a) or (b).

(2) Designate the table of secondary units as described in (a) or (b) but add the following letter suffix immediately after the hyphenated numerical suffix:

(-a) “C” if the table shows U.S. Customary units (e.g., Table 3.2-1C)

(-b) “M” if the table shows SI units (e.g., Table 6.7-1M)

The C&S Publishing XML system sets the table designator on the line above the table title. See Example SG4.1.

SG4-2.3 Table Titles

(a) Provide a unique title for each designated table. Do not use the table designator as the table title. Do not apply the same title to multiple tables.

(b) If the standard includes complementary U.S. Customary and SI tables, cite the type of units, preceded by an em dash, at the end of the table titles to create the unique titles required by (a).

EXAMPLE:

Table 6.1-1

Socket-Welding Elbows, Tees, and Crosses — SI Units

Table 6.1-1C

Socket-Welding Elbows, Tees, and Crosses — U.S. Customary Units

(c) Keep table titles concise and precise. Except as described in (b), do not include supplementary or parenthetical information in the table title. Instead, locate this information in a general note (see SG4-2.6.2).

(d) Set the table title Uc/lc [see SG1-1(a)(3)].

SG4-2.4 Table Content

SG4-2.4.1 Column Headings

(a) *General Principles.* For each column, provide a unique column heading that clearly identifies the data in the column. Do not use row headings (see *Incorrect* example below). Do not treat the table title as if it were the column heading. If a column heading applies to more than one column, span the column heading across two or more column subheadings.

EXAMPLES:

Incorrect: Row Headings

Attribute	Device Yield Load		Device Stiffness	
	Absolute	Rank Order	Absolute	Rank Order
Model Influence	High	Medium	High	Medium
Decision Consequence	High	High	Low	Low
Model Risk	High	Medium	Medium	Low

Correct: Column Headings

Attribute	Model Influence	Decision Consequence	Model Risk
Device yield load			
Absolute	High	High	High
Rank order	Medium	High	Medium
Device stiffness			
Absolute	High	Low	Medium
Rank order	Medium	Low	Low

Spanner Column Heading

Inside Diameter of Cast Fitting, <i>F</i> , mm (in.)	
Min.	Max.
10 (0.41)	11 (0.44)
14 (0.54)	15 (0.58)
17 (0.68)	18 (0.72)

(b) *Capitalization and Type Style.* Set column headings Uc/lc [SG1-1(a)(3)] and bold. If the column heading includes a variable, set the variable both bold and italic (see also SG3-4.1(a) and SG3-4.2(d)).

(c) *Order of Information.* Order the information in the column heading as follows:

- (1) title
- (2) variable, if applicable, set off by commas
- (3) abbreviated unit of measure, if applicable, preceded by a comma [see also (e)]

(4) Note reference [see SG4-2.6.3], if applicable, enclosed in brackets but not preceded by a comma

(d) Words vs. Abbreviations

(1) *General Principles.* Spell out words in column headings except units of measure and the words “Maximum” and “Minimum” if used as described in (2)(-b). You may abbreviate additional words only if abbreviation is necessary to accommodate all column headings. Consult the Managing Editor for guidance.

(2) Treatment of “Maximum” and “Minimum”

(-a) If a column heading specifies “Minimum” or “Maximum,” place the spelled-out word at the beginning of the heading (e.g., **Maximum Thickness, *t*, in.**, not **Thickness, *t*, max., in.**).

(-b) If “Maximum” and “Minimum” are used alone as column subheadings beneath a spanner heading [see (a)], abbreviate the words to “Max.” and “Min.” respectively.

(e) *Dual Units.* If a column lists dual units, cite both sets of units in the column heading. Give the abbreviation for the primary units first, followed by the abbreviation for the secondary units enclosed in parentheses. See also SG4-2.4.2(d).

(f) *Alignment.* Center and bottom-align column headings.

Example SG4.1 illustrates style rules (a) through (f).

SG4-2.4.2 Column Entries and Rows

(a) *General Principles.* Include in each column only the data identified by the column heading. If a column entry is not precisely the data identified by the column heading, the entry does not belong in the column.

(b) *Subheadings Within the Table.* You may use boldface subheadings within the table to group related information. Capitalize and boldface in-table subheadings in the same manner as column headings [see SG4-2.4.1(b)]. Consult the Managing Editor with questions regarding use of subheadings within a table.

(c) *Capitalization of Column Entries.* Capitalize the first word of each column entry. Set all subsequent words lowercase unless the rules in SG1-1(a) apply.

(d) *Dual-Unit Values.* List dual-unit values in a single column, not in separate columns. Give the values for the primary units first, followed by values for the secondary units enclosed in parentheses.

(e) *Order of Rows.* Order rows in a logical fashion, e.g., alphanumerically, chronologically, or hierarchically.

(f) *Variables and Abbreviations.* See SG4-2.6.1(a).

(g) *Empty Cells.* Place an ellipsis (...) in each empty cell of the table.

(h) Alignment

- (1) Top-align rows.

(2) Horizontal alignment of column entries varies based on the type of data and the length of the entries. The following are guidelines, not rigid principles. Consult the Managing Editor with questions regarding horizontal alignment of column entries.

(-a) Align columns of whole numbers or decimal fractions on the decimal.

(-b) Align columns of numerical ranges on the end dash [see [SG1-3.2\(d\)\(1\)](#)].

(-c) Align columns of dual units on the opening parenthesis.

(-d) Center columns of fractions and mixed numerals.

(-e) Center columns of text entries if the entries are of roughly the same number of characters (e.g., a column of “N/A”). Set columns of text entries flush left if the entries are of varying length or of more than one line.

If the alignments indicated in (-a) through (-d) detract from readability, set the entries flush left. In columns set flush left, the C&S Publishing XML system indents runover lines one em space.

SG4-2.5 Horizontal and Vertical Rules

(a) Include a table-wide horizontal rule above and below the column headings and below the last row of the table.

(b) Include a horizontal “spanner” rule below a column heading that spans column subheadings [see [SG4-2.4.1\(a\)](#)].

(c) Place a vertical rule between column headings connected by a single horizontal spanner rule [see (b)]. Extend the vertical rule only to the spanner rule, not to the table-wide rule below all column headings. See [Example SG4.2](#).

(d) Within the body of the table, use rules only if needed to clarify relationships between the data in the columns and rows. Consult the Managing Editor for guidance.

SG4-2.6 Legends, General Notes, and Referenced Notes

SG4-2.6.1 Legends

(a) Define in a legend any variable, acronym, or other abbreviation used in the table but not previously defined in the text.

(b) Precede the legend list with the label “Legend:” set flush left on its own line.

SG4-2.6.2 General Notes

(a) Set notes that apply to the table title or the entire table as general notes.

(b) List general notes below the bottom rule of the table.

(c) Precede a single general note with the label “GENERAL NOTE:” and run the text of the note into the line.

(d) Precede multiple general notes with the label “GENERAL NOTES:” set flush left on its own line. Designate the notes (a), (b), etc., and begin each note on a new line. The C&S Publishing XML system sets the first line of each note flush left and aligns runover lines on the first word of the note.

(e) State each general note as a complete sentence and end it with a period.

(f) If a general note includes a breakdown, designate the breakdown using the following modified designation scheme:

GENERAL NOTES:

(a) Text of note

(1) first-level breakdown item

(a) second-level breakdown item

(-1) third-level breakdown item

(-a) fourth-level breakdown item

SG4-2.6.3 Referenced Notes

(a) Set notes that apply to specific parts of the table as referenced notes.

(b) Place a bracketed note reference {e.g., “[Note (1)]”} at the end of the column heading or table entry to which a referenced note applies. Do not include the word “see” before the bracketed note reference. Number the note references from left to right across the column heads, and then left to right and down among the table entries. If citing more than one note at a single table location, use the following formats for the note references: “[Notes (1), (2)]”; “[Notes (1)–(3)]”.

NOTE: If space in a table is limited, you may shorten the note references throughout the table to the parenthetical number, e.g., “(1)”; “(1), (2)”; “(1)–(6).” Do not alternate between note-reference formats {e.g., “[Note (1)]” and “(1)"} within the same table.

(c) List the referenced notes below general notes, ordered and numbered (1), (2), etc., based on the order in which they are referenced in the table [see (b)].

(d) Precede a single referenced note with the label “NOTE: (1)” and run the text of the note into the line.

(e) Precede multiple referenced notes with the label “NOTES:” set flush left on its own line. Begin each note on a new line. The C&S Publishing XML system sets the first line of each note flush left and aligns runover lines on the first word of the note.

(f) State each referenced note as a complete sentence and end it with a period.

(g) Designate breakdowns in referenced notes in the same manner as breakdowns in text [see [SG2-2.2.1\(b\)](#)].

SG4-2.7 Long or Wide Tables

SG4-2.7.1 Tables Breaking Over Pages

(a) *Table Body*. If a table cannot fit on a single page, the C&S Publishing XML system autogenerates the following table elements on each runover page:

- (1) the table designator
- (2) the table title followed by “(Cont’d)”
- (3) the column headings, with horizontal rules above and below
- (4) the last table-body subheading, if any, from the previous page, followed by “(Cont’d)”
- (5) a table-wide horizontal rule below the last row of data

(b) **Table Notes.** If only the table’s general or referenced notes begin on or break to a new page, the C&S Publishing XML system autogenerates the following table elements on each runover page:

- (1) the table designator
- (2) the table title followed by “(Cont’d)”
- (3) a table-wide horizontal rule below the table title
- (4) the note label [e.g., “GENERAL NOTES” or “NOTES”; see [SG4-2.6.2](#) and [SG4-2.6.3](#)] followed by
 - (-a) a colon if the notes begin on the runover page
 - (-b) a colon and “(Cont’d)” if the notes continue from the preceding page

SG4-2.7.2 Landscaped Tables. If a table has too many columns to fit on a vertically oriented page, the C&S Publishing XML system sets the table in landscape orientation, i.e., rotated 90 deg left on the page, to accommodate the columns (see also [SG4-2.7.3](#)). Treat landscaped tables in the same manner as other designated tables (see [SG4-2](#) through [SG4-2.7.1](#)). See [Example SG4.1](#).

SG4-2.7.3 Spread Tables

(a) **General Principles.** A spread table comprises a series of multipage spreads, i.e., groupings of two or more consecutive pages needed to accommodate all columns. Use a spread table if a table has too many columns to fit on a landscaped page (see [SG4-2.7.2](#)). Treat spread tables in the same manner as other designated tables (see [SG4-2](#) through [SG4-2.7.1](#)), but see also (b). Consult the Managing Editor for guidance on the use of landscaped tables vs. spread tables.

(b) **Format.** The C&S Publishing XML system formats spread tables in the same manner as other designated tables but with the following changes:

(1) **Placement of Spread Tables.** The C&S Publishing XML system begins each spread table on a left-hand (verso) page. If the text page preceding the first page of a spread table is a verso page, the XML system inserts a right-hand (recto) page that reads “TABLE STARTS ON NEXT PAGE” so that the table starts on a verso page.

(2) **Table Designator and Title.** The C&S Publishing XML system sets the table designator and title, without the word “(Cont’d),” at the top of each page of the first spread within the table. The XML system adds the abbreviation “(Cont’d)” after the table title on each page of the subsequent spreads.

(3) **Line Numbers.** If including a “Line No.” column in a spread table, set it as the first column of each page of a spread. The C&S Publishing XML system can programmatically populate the line number column. Consult the Composition staff for further guidance.

(4) **Illustrations With Spread Tables.** See [SG4-2.9\(a\)\(1\)](#).

(5) **Legends, General Notes, and Referenced Notes.** The C&S Publishing XML System places the legend, general notes, or referenced notes on the last page of the table, after the final bottom rule of the table.

SG4-2.7.4 Snaked Tables. Snaked tables present narrow columns of data efficiently by breaking the columns after a given number of rows and continuing the columns from the top of the table. The column headings repeat above the snaked column data. The C&S Publishing XML system autogenerates the repeated column headings of snaked tables. See [Example SG4.3](#). Apply the following style rules to snaked tables:

(a) If a snaked table is a designated table, apply the style rules of [SG4-2](#). If a snaked table is an in-text table, apply the style rules of [SG4-3](#).

(b) Include a table-length vertical rule between the snaked columns to delineate the continuation of the columns.

SG4-2.8 Placement of Designated Tables

(a) **Location.** Place a designated table on the same page as its parent paragraph unless one of the following scenarios applies:

(1) If the table cannot fit on the same page as the parent paragraph, place it on the following page.

(2) If the standard or a section of the standard has few pages of text but multiple tables and figures, place the tables and figures at the end of the text.

If application of either (1) or (2) detracts from readability, consult the Managing Editor and Composition staff for further guidance.

(b) **Order.** Place designated tables in the order in which they are referenced in their parent paragraphs. If the text references one or more figures between references to designated tables, place the tables and figures in the order in which they are referenced. For example, if the text references Table 2-3.2-1 and Figure 2-3.2-1 in one sentence and Table 2-3.2-2 in the next sentence, place the tables and figure in the following order in the page layout: Table 2-3.2-1 first, Figure 2-3.2-1 second, and Table 2-3.2-2 third.

SG4-2.9 Tables With Illustrations

(a) **General Principles.** A table may include one or more illustrations to support the table data. Apply the following rules to tables with illustrations:

(1) If one or more illustrations apply to the entire table, place the illustrations immediately beneath the table title. If the table is a spread table, the C&S Publishing XML system will repeat the illustration on the first page of each spread of the table. If the table is not a spread table, the XML system will place the illustrations only on the first page of the table.

(2) If illustrations apply to individual rows of the table, create a column for the illustrations and place the illustrations in individual cells within the column. Label the column with a unique heading.

(b) Distinguishing Between a Figure Within a Table and a Table Within a Figure

(1) If the purpose of a figure is to support a table, treat the figure as an illustration of the table [see (a)(1)]. See [Example SG4.1](#).

(2) If the purpose of a table is to support a figure, treat the table as you would an in-text table (see [SG4-3](#)). Place the table immediately after the figure, before any legend, general notes, or referenced notes. See [Example SG4.4](#).

SG4-3 IN-TEXT TABLES

Treat in-text tables in the same manner as designated tables (see [SG4-2](#)) but with the following changes:

(a) Place an in-text table immediately after the sentence or paragraph that introduces the table data.

(b) Omit the following:

(1) table designator and title

(2) horizontal rule above the column headings and below the last row of the table

SUBPART SG5

FIGURES AND FORMS

SG5-1 GLOSSARY OF TERMS USED IN THIS SUBPART

callout: text used within a figure to describe an area of the figure.

parent paragraph: the paragraph that introduces the data in or topic of a designated table or figure. The designator of the table or figure is based on the designator of the parent paragraph.

SG5-2 FIGURE TYPES AND FORMATS

(a) *General Principles*. See the following documents in C&S Connect¹ for acceptable figure types and formats:

(1) Guidelines for Presenting Proposed Revisions for Ballot and Submittal of Approved Revisions to C&S Publishing

(2) ASME Artwork Specification

(b) *Color Figures*. ASME standards published only as PDFs may include color figures. Consult the Managing Editor regarding use of color figures in print standards.

SG5-3 FIGURE DESIGNATORS

(a) *General Principles*. ASME standards designate, or number, figures in the same manner as tables, i.e., based on the figure's parent paragraph. This paragraph-based numbering scheme facilitates page layout, provides unique designators for cross-referencing, and enables the user to locate the text associated with the figure. You must cite each figure at least once in text to establish the figure's parent paragraph. The parent paragraph is usually but not always the paragraph in which the figure is first cited.

(b) *Format*. Format figure designators as follows:

(1) If the parent paragraph introduces only one figure, designate the figure using the paragraph designator followed by the numerical suffix "-1." For example, if this paragraph introduced a figure, it would be designated Figure SG5-3-1.

(2) If the parent paragraph introduces more than one figure, designate the figures using the paragraph designator and successive numerical suffixes, starting with "-1" for the first figure cited and continuing chronologically for each subsequent figure.

¹To access the cited documents, go to <https://go.asme.org/standards-procedures> and select "Guides" from the "Sub-Folders" drop-down menu.

EXAMPLE:

SECTION 3-0.1: SCOPE

This Standard establishes performance requirements for chain, wire rope, and web strap lever hoists (see Figures 3-0.1-1 through 3-0.1-4).

(3) If the parent paragraph introduces a mix of figures and tables, number the figures and tables separately, i.e., begin the numerical suffixes for the figure designators at "-1" and those for the table designators at "-1."

EXAMPLE:

2-3 TABLES AND FIGURES

The symbols, terms, definitions, equations, references, and units of variables used in this Code are listed in Table 2-3-1. See Figures 2-3-1 through 2-3-5 for a graphical definition of terms.

The C&S Publishing XML system sets the figure designator on the line above the figure title. See [Example SG5.1](#).

SG5-4 FIGURE TITLES

(a) Provide a unique title for each figure. Do not use the figure designator as the figure title. Do not apply the same title to multiple figures. You may group multiple figures with similar titles into a single multi-illustration figure (see [SG5-6](#)).

(b) Keep figure titles concise and precise. Do not include parenthetical or other supplementary information in the figure title. Instead, locate this information in a general note (see [SG5-7.2](#)).

(c) Set the figure title Uc/lc [see [SG1-1\(a\)\(3\)](#)].

EXAMPLE:

Figure 1-9.7-1

Fatigue Curves for Design of Pipe 2 in. (50 mm) and Smaller

The C&S Publishing XML system sets the figure title above the figure. See [Example SG5.1](#).

SG5-5 FIGURE CALLOUTS AND AXIS LABELS

(a) *Callouts*

(1) *Capitalization*. Capitalize the first word of each callout. Set all subsequent words of the callout in lower-case unless the rules in [SG1-1\(a\)](#) apply.

(2) *Dual-Unit Values.* If the standard provides dual-unit values, include both values in any callout that cites a value. Give the values for the primary units first, followed by values for the secondary units enclosed in parentheses.

(3) *Variables and Abbreviations.* Define in a legend any variable or abbreviation used in a callout but not previously defined in text. See [SG5-7.1](#).

(4) *Runover Lines.* If a callout runs more than one line, indent the runover lines one em space.

(b) *Axis Labels on Graphs.* Treat the *x*- and *y*-axis labels on graphs in the same manner as callouts but with the following changes:

(1) Set the label *Uc/lc* [see [SG1-1\(a\)\(3\)](#)].

(2) Center the label on the axis line.

SG5-6 MULTI-ILLUSTRATION FIGURES

Treat figures comprising multiple illustrations in the same manner as single-illustration figures (see [SG5-2](#) through [SG5-5](#)) but with the following additions:

(a) *Positioning.* Set the illustrations from left to right. If the illustrations will not fit side by side, stack the illustrations. See [Examples SG5.2](#) and [SG5.3](#).

(b) *Captions*

(1) Identify each illustration with a caption set in boldface and centered beneath the illustration.

(2) Letter the captions (a), (b), etc., from left to right. In text citations, cite both the figure designator and the illustration letter (e.g., “see Figure 2-3.2-1, illustration (a)”).

(3) Set the captions *Uc/lc* [see [SG1-1\(a\)\(3\)](#)].

SG5-7 LEGENDS, GENERAL NOTES, AND REFERENCED NOTES

SG5-7.1 Legends

(a) Define in a legend any abbreviation or variable used in the figure but not previously defined in the text.

(b) Precede the legend list with the label “Legend:” set flush left on its own line.

SG5-7.2 General Notes

(a) Set notes that apply to the figure title or the entire figure as general notes.

(b) List general notes below the figure.

(c) Precede a single general note with the label “GENERAL NOTE:” and run the text of the note into the line.

(d) Precede multiple general notes with the label “GENERAL NOTES:” set flush left on its own line. Designate the notes (a), (b), etc., and begin each note on a new line. The C&S Publishing XML system sets the first line of each note flush left and aligns run-over lines on the first word of the note.

(e) State each general note as a complete sentence and end it with a period.

(f) If a general note includes a breakdown, designate the breakdown using the following modified designation scheme:

GENERAL NOTES:

(a) Text of note

(1) first-level breakdown item

(a) second-level breakdown item

(-1) third-level breakdown item

(-a) fourth-level breakdown item

SG5-7.3 Referenced Notes

(a) Set notes that apply to specific parts of the figure as referenced notes.

(b) Place a bracketed note reference {e.g., “[Note (1)]”} at the end of the callout (or caption) or next to the area of the figure to which the referenced note applies. Do not include the word “see” before the bracketed note reference. Number the note references from left to right and then down among the callouts. If citing more than one note at a single figure location, use the following formats for the note reference: “[Notes (1), (2)]”; “[Notes (1)–(6)]”.

(c) List the referenced notes below general notes, ordered and numbered (1), (2), etc., based on the order in which they are referenced in the figure [see (b)].

(d) Precede a single referenced note with the label “NOTE: (1)” and run the text of the note into the line.

(e) Precede multiple referenced notes with the label “NOTES:” set flush left on its own line. Begin each note on a new line. The C&S Publishing XML system sets the first line of each note flush left and aligns run-over lines on the first word of the note.

(f) State each referenced note as a complete sentence and end it with a period.

(g) Designate breakdowns in referenced notes in the same manner as breakdowns in text [see [SG2-2.2.1\(b\)](#)].

SG5-8 LONG OR WIDE FIGURES

SG5-8.1 Figures Breaking Over Pages

(a) If a figure comprises multiple illustrations that cannot fit on a single page, the C&S Publishing XML system autogenerates the figure designator and figure title followed by “(Cont’d)” on each runover page.

(b) If only the figure’s general or referenced notes begin on or break to a new page, the C&S Publishing XML system autogenerates the following figure elements on each runover page:

(1) the figure designator

(2) the figure title followed by “(Cont’d)”

(3) the note label (e.g., “GENERAL NOTES” or “NOTES”; see [SG5-7.2](#) and [SG5-7.3](#)) followed by

(-a) a colon if the notes begin on the runover page

(-b) a colon and “(Cont’d)” if the notes continue from the preceding page

SG5-8.2 Landscaped Figures

If a figure is too wide to fit vertically on a page, the C&S Publishing XML system sets the figure in landscape orientation, i.e., rotated 90 deg left on the page. Treat landscaped figures in the same manner as other figures (see [SG5-2](#) through [SG5-8.1](#)). See [Example SG5.4](#).

SG5-9 FIGURES WITHIN A TABLE

See [SG4-2.9\(b\)](#).

SG5-10 PLACEMENT OF FIGURES

Place figures in page layout in the same manner as for designated tables (see [SG4-2.8](#)).

SG5-11 FORMS

A form comprises a designator, a title, and a series of labeled fill-in fields. A form may also include one or more illustrations, a legend, and general or referenced notes.

Though a form may resemble a table, C&S Publishing processes all forms as artwork. Therefore, treat forms in the same manner as figures but with the following changes:

(a) Include the form designator, title, legend, and general or referenced notes within the image.

(b) Include a double rule between the form title and the form content.

(c) In BPVC Sections, include a parenthetical date (month and year) in the lower left corner of each page of a form to indicate the edition of the most recent update to that page.

(d) In page layout, set each page of a form on a standalone page.

See [Examples SG5.5](#) and [SG5.6](#).

Each form is unique and may present unique challenges. Consult the Managing Editor for additional guidance on forms.

MANDATORY APPENDIX I

ABBREVIATIONS FOR UNITS OF MEASURE

I-1 GUIDE TO USING THIS APPENDIX

[Table I-1-1](#) lists the abbreviations for units of measure commonly used in ASME codes and standards. The table is organized as follows:

(a) U.S. Customary units are listed in the first column of the table, and the associated abbreviations are listed, unparenthesized, in the third column.

(b) SI units are listed in the second column, and the associated abbreviations are parenthesized in the third column.

(c) Units that are the same for both U.S. Customary and SI are listed in both the first and second columns.

[Table I-1-1](#) begins on the next page. See [SG1-2.1\(a\)](#) for treatment of units not listed in the table.

Table I-1-1
Abbreviations for Units of Measure

U.S. Customary Units	SI Units	Abbreviations
ampere	ampere	A
ampere per square foot	ampere per square meter	A/ft ² (A/m ²)
Angstrom	Angstrom	Å
arcminute	arcminute	arcmin
arcsecond	arcsecond	arcsec
atmosphere	atmosphere	atm
British thermal unit	joule	Btu (J)
	kilojoule	Btu (kJ)
British thermal unit per cubic foot	joule per cubic meter	Btu/ft ³ (J/m ³)
	kilojoule per cubic meter	Btu/ft ³ (kJ/m ³)
British thermal unit per hour	watt	Btu/hr (W)
	kilowatt	Btu/hr (kW)
British thermal unit per pound mass	kilojoule per kilogram	Btu/lbm (kJ/kg)
coulomb	coulomb	C
cubic foot	cubic meter	ft ³ (m ³)
cubic foot per hour	cubic meter per hour	ft ³ /hr (m ³ /h)
cubic foot per minute	cubic meter per minute	ft ³ /min (m ³ /min)
cubic foot per pound mass	cubic meter per kilogram	ft ³ /lbm (m ³ /kg)
cubic inch	cubic millimeter	in. ³ (mm ³)
	cubic centimeter	in. ³ (cm ³)
cubic yard	cubic meter	yd ³ (m ³)
cycles per hour	cycles per hour	cycles/hr (cycles/h)
decibel	decibel	dB
degree (angle)	degree (angle)	deg
degree per minute	degree per minute	deg/min
degree per second squared	degree per second squared	deg/sec ² (deg/s ²)
electronvolt	electronvolt	eV
Fahrenheit	Celsius, Centigrade	°F (°C) [Note (1)]
Fahrenheit per foot	Celsius per meter	°F/ft (°C/m)
fluid ounce	liter	fl oz (L)
	milliliter	fl oz (mL)
foot	meter	ft (m)
	centimeter	ft (cm)
foot candle	lux	fc (lx)
foot per second	meter per second	ft/sec (m/s)
	centimeter per second	ft/sec (cm/s)
foot per second per second	meter per second per second	ft/sec ² (m/s ²)
foot per second squared	meter per second squared	ft/sec ² (m/s ²)
foot-pound	joule	ft-lb (J)
	newton-meter	ft-lb (N·m)
gallon	liter	gal (L)
	cubic meter	gal (m ³)
gallon per flush	liter per flush	gpf (Lpf)
gallon per hour	liter per hour	gph (L/h)
	cubic meter per hour	gph (m ³ /h)
gallon per minute	liter per minute	gpm (L/m)
	cubic meter per minute	gpm (m ³ /min)

Table I-1-1
Abbreviations for Units of Measure (Cont'd)

U.S. Customary Units	SI Units	Abbreviations
gigahertz	gigahertz	GHz
gravitational force	gravitational force	<i>g</i> [Note (1)]
henries per meter (unit for magnetic permeability)	henries per meter (unit for magnetic permeability)	H/m or H.m ⁻¹
hertz	hertz	Hz
horsepower	kilowatt	hp (kW)
hour	hour	hr (h)
inch	millimeter	in. (mm)
	centimeter	in. (cm)
inch of mercury	millimeter of mercury	in. Hg (mm Hg)
inch per minute	millimeter per minute	in./min (mm/min)
inch per pound	millimeter per newton	in./lb (mm/N)
inch per second	millimeter per second	in./sec (mm/s)
inch-pound	newton-meter	in.-lb (N·m)
inch-pound force	newton-meter	in.-lbf (N·m)
kilohertz	kilohertz	kHz
kilovolt	kilovolt	kV
kilovolt per foot	kilovolt per meter	kV/ft (kV/m)
kilowatt	kilowatt	kW [Note (2)]
kilowatt-hour	kilowatt-hour	kW·h
kip per square inch	megapascal	ksi (MPa)
megaelectronvolt	megaelectronvolt	MeV
megahertz	megahertz	MHz
megavolt	megavolt	MV
microhertz	microhertz	μHz
microinch	micrometer	μin. (μm)
microradian	microradian	μrad
microsecond	microsecond	μsec (μs)
micro-siemens per inch	micro-siemens per centimeter	μS/in. (μS/cm)
mile	kilometer	mi (km)
mile per hour	kilometer per hour	mph (km/h)
millisecond	millisecond	msec (ms)
milli-siemens per inch	milli-siemens per centimeter	mS/in. (mS/cm)
millivolt per inch	millivolt per meter	mV/in. (mV/m)
milliwatt	milliwatt	mW
mils	millimeter	mils (mm)
minute	minute	min
mole	mole	mol
newtons per ampere squared (unit for magnetic permeability)	newtons per ampere squared (unit for magnetic permeability)	N.A ⁻²
ohm	ohm	Ω
ohm inch	ohm meter	Ωin. (Ωm)
ounce	gram	oz (g)
parts per billion	parts per billion	ppb
parts per million	parts per million	ppm
pint	milliliter	Pt (mL)
pound	gram	lb (g)
	kilogram	lb (kg)

Table I-1-1
Abbreviations for Units of Measure (Cont'd)

U.S. Customary Units	SI Units	Abbreviations
pound-foot per second	kilogram-meter per second	lb-ft/sec (kg·m/s)
pound-force	newton	lbf (N)
pound-force per square inch	gigapascal	psi (GPa)
	megapascal	psi (MPa)
	kilopascal	psi (kPa)
		lbf/in. ² (kPa)
	bar	psi (bar)
pound-force per square inch absolute	gigapascal	psia (GPa)
	megapascal	psia (MPa)
	kilopascal	psia (kPa)
	bar	psia (bar)
pound-force per square inch gauge	gigapascal	psig (GPa)
	megapascal	psig (MPa)
	kilopascal	psig (kPa)
	bar	psig (bar)
pound mass	kilogram	lbm (kg)
pound mass per cubic foot	kilogram per cubic meter	lbm/ft ³ (kg/m ³)
pound mass per cubic inch	gram per cubic centimeter	lbm/in. ³ (g/cm ³)
pound mass per gallon	kilogram per cubic meter	lbm/gal (kg/m ³)
pound mass per hour	kilogram per hour	lbm/hr (kg/h)
radian	radian	rad
radian per second	radian per second	rad/sec (rad/s)
radian per second per second	radian per second per second	rad/sec ² (rad/s ²)
Rankine	kelvin	°R (K) [Note (1)]
revolution per minute	revolution per minute	rpm
second	second	sec (s)
siemens per foot	siemens per meter	S/ft (S/m)
siemens per inch	siemens per centimeter	S/in. (S/cm)
slug per cubic foot	kilogram per cubic meter	slug/ft ³ (kg/m ³)
square foot	square meter	ft ² (m ²)
square inch	square millimeter	in. ² (mm ²)
	square centimeter	in. ² (cm ²)
square yard	square meter	yd ² (m ²)
standard cubic foot per minute	cubic decimeter per second	SCFM (dm ³ /s)
tesla	tesla	T
ton	metric ton	t
torr	torr	Torr
volt	volt	V
volt per foot	volt per meter	V/ft (V/m)
watt	watt	W
weber	weber	Wb
yard	meter	yd (m)
year	year	yr (y)

NOTES:

- (1) Omit the space between a value and the following units of measure: °C, °F, °R, and *g*. (See [SG1-2.1](#) for style rules for abbreviated units of measure.)
- (2) A kWe is 1,000 watts of electrical power. A kWm is 1,000 watts of mechanical power generated from fuel by mechanical processes. The unit kWt is used for thermal power.

NONMANDATORY APPENDIX A EXAMPLES

Example WG1.1 Scope

ASME NM.2-2020

Chapter 1 Scope and Definitions

1-1 SCOPE

(a) This Standard provides requirements for the design, materials, manufacture, fabrication, installation, examination, and testing of glass-fiber-reinforced thermosetting-resin (FRP) piping systems.

(b) FRP piping, as used in this Standard, includes pipe, flanges, bolting, gaskets, valves, fittings, special connecting components, and the pressure-containing or pressure-retaining portions of other piping components, whether manufactured in accordance with references cited in this Standard or specially designed. It also includes hangers and supports and other items necessary to prevent overstressing the pressure-containing components.

(e) products with fiber-reinforcement materials that are not made from glass

(f) nonmetallic pressure vessels, valves, and specialty components covered by other ASME codes and standards, such as ASME BPVC, Section X and ASME RTP-1

(g) piping for which the maximum internal pressure exceeds 1 700 kPa (250 psi)

(h) piping for which the algebraic product of internal pressure [in kilopascals gauge (pounds per square inch gauge)] and internal diameter [in meters (inches)] exceeds 1 262 kPag-m (7,200 psig-in.)

(i) piping used as ductwork conveying air or other gases at pressures within 6.89 kPag (1 psig) of the pressure of the surrounding atmosphere

1-1.1 Content and Coverage

(a) This Standard addresses pipe and piping components that are produced as standard products, as well as custom products that are designed for a specific application. It covers FRP pipe and piping components manufactured by contact molding, centrifugal casting, filament winding, and other methods. Its intent is to provide a uniform set of requirements for FRP pipe and piping components that can be adopted by reference in the various piping codes, including sections of the ASME B31 Code for Pressure Piping. This Standard is published as a separate document to reduce duplication between piping codes.

(b) Requirements of this Standard apply to FRP piping systems typically used within the scope of the various sections of the ASME B31 Code for Pressure Piping (ASME B31.1, ASME B31.3, ASME B31.4, ASME B31.5, ASME B31.8, and ASME B31.9) and selected piping systems designed to the ASME Boiler and Pressure Vessel Code (BPVC), Section III, Division 1, Subsection ND.

1-1.2 Exclusions

This Standard does not provide requirements for the following:

- (a) metallic pipe
- (b) thermoplastics, ceramics, and other nonmetallic materials used to fabricate pipe and piping components
- (c) dual laminate construction that combines thermoplastic linings with FRP pipe and fittings
- (d) reinforced polymer mortar pipe

1-2 TERMS AND DEFINITIONS

(20)

Commonly used terms relating to FRP piping are defined below. Some terms are defined with specific reference to piping. The definitions generally agree with those in ASME BPVC, Section X; ASME RTP-1; ASTM D883; and ASTM F412. Definitions taken unchanged from other standards are indicated by a footnote.

adhesive: a material designed to join together two other component materials by surface attachment (bonding).

adhesive joint: a bonded joint made using an adhesive on the surfaces to be joined.

assembly: synonymous with fabrication.

*binder*¹: in a reinforced plastic, the continuous phase that holds together the reinforcement.

*bloom*¹: a visible exudation or efflorescence on the surface of a material.

*bonder*²: one who performs a manual or semiautomatic bonding operation.

*bonding procedure*²: the detailed methods and practices involved in the production of a bonded joint.

Bonding Procedure Specification (BPS): a document providing in detail the required variables and procedures for the bonding process to ensure repeatability in the bonding procedure.

¹ This definition is from ASTM D883.

² This definition is from ASME B31.3.

Example WG1.2 Reference List

ASME SBS-2022

NONMANDATORY APPENDIX A COATINGS AND LININGS

A-1 SCOPE

This Appendix presents procedures and practices for achieving effective corrosion and abrasion protection and for promoting product flow in steel bulk solids storage containers by the application of exterior coatings and interior linings.

This Appendix is intended to serve only as a guide. Detailed coating and lining specifications are not included. It is recommended that project-specific specifications for coatings and linings be prepared. This Appendix does not designate specific coatings or linings for every situation due to the wide variety of container service environments and performance requirements.

For recoating of existing containers, specific materials, procedures, and practices are required and are outside the scope of this Standard. Refer to AWWA D102 or other applicable references for information.

A-2 REFERENCES

The most recent edition or revision of the following standards, codes, or specifications shall, to the extent specified, form a part of this Appendix:

- API Standard 2015. Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks. American Petroleum Institute.
- ASTM D2240. Test Method for Rubber Property-Durometer Hardness. American Society for Testing and Materials.
- ASTM D2583. Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor. American Society for Testing and Materials.
- ASTM D3363. Test Method for Film Hardness by Pencil Test. American Society for Testing and Materials.
- ASTM D4414. Practice for Measurement of Wet Film Thickness of Organic Coating by Notch Gauges. American Society for Testing and Materials.
- ASTM D5402. Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs. American Society for Testing and Materials.
- AWWA D102. Coating Steel Water-Storage Tanks. American Water Works Association.
- AWWA D103. Factory-Coated Bolted Steel Tanks for Water Storage. American Water Works Association.

- NACE Comm. Report 6D163. A Manual for Painter Safety (Cat. No. 24014). Association for Materials Protection and Performance.
- NACE Comm. Report 6F164. Curing of Interior Tank Linings (Cat. No. 24112). Association for Materials Protection and Performance.
- NACE RP-01-84. Repair of Lining Systems. Association for Materials Protection and Performance.
- NACE RP-01-88. Discontinuity (Holiday) Testing of Protective Coatings. Association for Materials Protection and Performance.
- NACE RP-02-87. Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using a Replica Tape. Association for Materials Protection and Performance.
- NACE RP-02-88. Inspection of Linings on Steel and Concrete. Association for Materials Protection and Performance.
- NACE TM-01-74. Laboratory Methods for the Evaluation of Protective Coatings Used as Lining Material in Immersion Service. Association for Materials Protection and Performance.
- SSPC PA 1. Shop, Field, and Maintenance Painting. Association for Materials Protection and Performance.
- SSPC PA 2. Measurement of Dry Paint Thickness with Magnetic Gages. Association for Materials Protection and Performance.
- SSPC PA 3. A Guide to Safety in Paint Application. Association for Materials Protection and Performance.
- SSPC SP 1. Solvent Cleaning. Association for Materials Protection and Performance.
- SSPC VIS 1. Visual Standard for Abrasive Blast Cleaned Steel. Association for Materials Protection and Performance.

A-3 DEFINITIONS

abrasion (erosion): wearing away of the bulk solids container base metal by rubbing or scraping from the contained bulk solids material.

anchor pattern: surface profile or roughness of the surface to be coated or lined after the surface has been abrasive blasted.

Example WG2.1
Title Page

ASME PCC-3-2022
(Revision of ASME PCC-3-2017)

Inspection Planning Using Risk-Based Methods

AN AMERICAN NATIONAL STANDARD



**The American Society of
Mechanical Engineers**

Two Park Avenue • New York, NY • 10016 USA

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**Example WG2.4
Foreword**

FOREWORD

In October 2016, the American Society of Mechanical Engineers (ASME) received a proposal to address new digital data needs within the design and manufacturing industry. The ASME Council on Standards and Certification approved the formation of a model-based enterprise (MBE) standards committee on February 28, 2018. The ASME MBE Standards Committee's task is to develop standards or related products that provide rules, guidance, and examples for the creation, use, and reuse of model-based data sets, data models, and related elements within an MBE.

ASME MBE-1 provides a framework that enables the development of MBE architectures and specifications for the elements of an MBE. This Standard is intended for MBE standard developers, MBE solution providers, and MBE system architects, as well as other professionals who want to understand structural elements for representing an MBE.

ASME MBE-1-2022 was approved by the American National Standards Institute as an American National Standard on April 5, 2022.

Example WG2.5
Committee Correspondence Page

CORRESPONDENCE WITH THE B31 COMMITTEE

General. ASME codes and standards are developed and maintained by committees with the intent to represent the consensus of concerned interests. Users of ASME codes and standards may correspond with the committees to propose revisions or cases, report errata, or request interpretations. Correspondence for this Code should be sent to the staff secretary noted on the committee's web page, accessible at <https://go.asme.org/B31committee>.

Revisions and Errata. The committee processes revisions to this Code on a continuous basis to incorporate changes that appear necessary or desirable as demonstrated by the experience gained from the application of the Code. Approved revisions will be published in the next edition of the Code.

In addition, the committee may post errata on the committee web page. Errata become effective on the date posted. Users can register on the committee web page to receive e-mail notifications of posted errata.

This Code is always open for comment, and the committee welcomes proposals for revisions. 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 background information and supporting documentation.

Cases

(a) The most common applications for cases are

(1) to permit early implementation of a revision based on an urgent need

(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Code

(4) to permit the use of a new material or process

(b) Users are cautioned that not all jurisdictions or owners automatically accept cases. Cases are not to be considered as approving, recommending, certifying, or endorsing any proprietary or specific design, or as limiting in any way the freedom of manufacturers, constructors, or owners to choose any method of design or any form of construction that conforms to the Code.

(c) A proposed case shall be written as a question and reply in the same format as existing cases. The proposal shall also include the following information:

(1) a statement of need and background information

(2) the urgency of the case (e.g., the case concerns a project that is underway or imminent)

(3) the Code and the paragraph, figure, or table number(s)

(4) the edition(s) of the Code to which the proposed case applies

(d) A case is effective for use when the public review process has been completed and it is approved by the cognizant supervisory board. Approved cases are posted on the committee web page.

Interpretations. Upon request, the committee will issue an interpretation of any requirement of this Code. An interpretation can be issued only in response to a request submitted through the online Interpretation Submittal Form at <https://go.asme.org/InterpretationRequest>. Upon submitting the form, the inquirer will receive an automatic e-mail confirming receipt.

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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.

Interpretations are published in the ASME Interpretations Database at <https://go.asme.org/Interpretations> as they are issued.

Example WG2.5
Committee Correspondence Page (Cont'd)

Committee Meetings. The B31 Standards Committee regularly holds meetings that are open to the public. Persons wishing to attend any meeting should contact the secretary of the committee. Information on future committee meetings can be found on the committee web page at <https://go.asme.org/B31committee>.

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Example SG1.1 List of Abbreviations and Acronyms

ASME PTC 52-2020

uncertainty, random, 2S: an estimate of the $\pm$ limits of random error with a defined level of confidence. Often given for 2σ (2 standard deviations) confidence level of about 95%.

uncertainty, systematic, B: an estimate of the $\pm$ limits of systematic error with a defined level of confidence (usually 95%).

uncertainty, test: the uncertainty associated with a corrected test result.

variable: a quantity subject to variation such that it can have different values that can be measured or counted. The quantity may be calculated from a number of measurands, where a measurand is a particular quantity that is being measured or estimated.

verification: a set of operations that establishes evidence by calibration or inspection that specified requirements have been met.

working fluid: gas or liquid stream from which work is extracted, such as by powering a gas or steam turbine.

2-2 SYMBOLS

See [Table 2-2-1](#) for definitions of the symbols used in this Code.

2-3 ABBREVIATIONS AND ACRONYMS

ANI = aperture normal irradiance
 Aux = auxiliary load — electric or thermal
 CSP = concentrating solar power
 DNI = direct normal irradiance
 HTF = heat transfer fluid
 MDPT = multiday performance test
 PTC = performance test code
 RSR = rotating shadowband radiometer
 RTD = resistance temperature detector
 SF = solar field
 STPT = short-term performance test
 SWSR = solar-weighted specular reflectance
 TES = thermal energy storage
 TOD = time of delivery

Example SG1.2

Placement of Footnote and Endnote References: General Rule

ASME BPVC.IV-2021

ARTICLE 7

CONTROLS

HLW-700 CONTROLS

HLW-701 Temperature Control

- (21) **HLW-701.1** Each individual automatically fired water heater shall have a high temperature limit control that is separate from the operating control used for normal water heater operation. The temperature range of the high temperature limit control. The high temperature limit control shall cut off the fuel supply at or below the designed maximum water temperature as indicated on the water heater's Manufacturer's Data Report. This control shall be constructed to prevent a temperature setting above the maximum.

(a) On gas-fired water heaters, the high temperature limit control when actuated shall shut off the fuel supply with a shutoff means other than the operating control valve. Separate valves may have a common body.

(b) On electrically heated water heaters, the high temperature limit control when actuated shall cut off all power to the operating controls.

(c) On oil-fired water heaters, the high temperature limit control when actuated shall cut off all current flow to the burner mechanism.

(d) On indirect water heating systems, the high temperature limit control when activated shall cut off the source of heat.

HLW-702 Limit Controls

Limit controls used with electric circuits should break the hot or line sides of the control circuit.

HLW-703 Controls and Heat Generating Apparatus

(a) All water heaters should be equipped with suitable primary (flame safeguard) safety controls, safety limit switches, and burners, or electric elements as required by a nationally recognized standard.³⁰

(b) The symbol of the certifying organization¹⁴ that has investigated such equipment as having complied with a nationally recognized standard shall be affixed to the equipment and shall be considered as evidence that the controls and heat generating apparatus were manufactured in accordance with that standard.

HLW-704 Electrical Wiring

HLW-704.1 Electrical Code Compliance. All field wiring for controls, heat generating apparatus, and other appurtenances necessary for the operation of the water heater should be installed in accordance with the provisions of the National Electrical Code and/or should comply with the applicable local electrical codes. All water heaters supplied with factory mounted and wired controls, heat generating apparatus, and other appurtenances necessary for the operation of the water heaters should be installed in accordance with the provisions of the nationally recognized standards such as those of HLW-703.³⁰

Example SG1.3

Placement of Footnote and Endnote References: Exception

ASME NM.2-2020

- (a) Type I. See ASME NM.3.2, SC-582.
 (b) Type II. See ASME NM.3.2, SC-582.
 (c) Type III. See [Mandatory Appendix IV](#).

*lay*¹:

(a) the length of twist produced by stranding filaments, such as fibers, wires, or roving; length of twist of a filament is usually measured as the distance parallel to the axis of the strand between successive turns of the filament.

(b) the angle that such filaments make with the axis of the strand during a stranding operation.

*lay up*¹: in reinforced plastics, to assemble layers of resin-impregnated material for processing.

*lay-up*¹: in reinforced plastics, an assembly of layers of resin-impregnated material ready for processing.

NOTE: Within this Standard, the noun *lay-up* is hyphenated to differentiate it from the verb *lay up*.

listed components: piping components manufactured in accordance with the specifications listed in [Table 4-1.1-1](#).

long-term hydrostatic pressure (LTHP): the estimated internal pressure of the piping product that, when applied continuously in accordance with ASTM D2992, Procedure B, will cause failure of the product after a specified number of hours. The specified number of hours and the extrapolation of failure results out to the specified number of hours are the same as for the long-term hydrostatic strength.

long-term hydrostatic strength (LTHS): the hoop stress that when applied continuously is calculated to cause the failure of the pipe in a specified number of hours, as set by the product standard. These strengths are usually obtained by extrapolation of log-log regression equations or plots of actual failure times for a range of stresses out to the selected interval.

lower deviated value (LDV): the test mean value less two standard deviations [see [para. 2-2.3.3\(c\)](#)].

may: used to denote permission; neither a requirement nor a recommendation.

manufacturing: the production of piping components by combining constituent materials using processes such as contact molding, filament winding, compression molding, and centrifugal casting.

pipe-supporting elements: pipe-supporting elements consist of fixtures and structural attachments as follows:

(a) *fixtures*: fixtures include elements that transfer the load from the pipe or structural attachment to the supporting structure, tank, vessel, or equipment. They include hanging-type fixtures, such as hanger rods, spring hangers, sway braces, turnbuckles, struts, guides, and anchors; and bearing-type fixtures, such as saddles, bases, brackets, and sliding supports.

(b) *structural attachments*: structural attachments include elements that are bonded, bolted, or clamped to the pipe, such as clips, lugs, rings, clamps, clevises, straps, and stanchions.

pressure design basis (PDB): an internal pressure developed for a fiberglass piping product and multiplied by a service (design) factor to obtain a hydrostatic design pressure. The PDB is the long-term hydrostatic pressure determined in accordance with ASTM D2992; ASTM D2992 allows the long-term hydrostatic pressure to be obtained on a cyclic stress (Procedure A) or constant stress (Procedure B) basis.

pressure rating (PR): the estimated maximum pressure in a piping component that can be exerted continuously with a high degree of certainty that failure of the piping component will not occur.

Procedure Qualification Record (PQR): a record of the bonding data used to bond a test piece. The PQR is a record of variables recorded during the bonding of the test pieces. It also contains the test results of the tested specimens. Recorded variables normally fall within a small range of the actual variables that will be used in production bonding.

reinforced thermoset resin pipe: a term used synonymously with FRP pipe.

*reinforcement*²: glass fibers having the form of chopped roving, continuous roving, fabric, or chopped-strand mat. These fibers are added to the resin matrix to strengthen and improve the properties of the resin.

*resin*³: the matrix of the laminate.

restrained piping system: a piping system or portion thereof that includes no changes in direction and is restrained from axial movement.

service (design) factor: a number not greater than 1.0 that is multiplied by the long-term hydrostatic strength (or long-term hydrostatic pressure) to obtain the hydrostatic design stress (or hydrostatic design pressure). The factor may vary depending on the service conditions, hazard, length of service desired, and properties of the pipe.

shall: "shall" or "shall not" is used to indicate that a provision or prohibition is mandatory.

short-term hydrostatic strength (STHS): the lower deviated value (LDV) of the tensile strength of the pipe in the hoop direction when the pipe is tested in accordance with ASTM D1599 [see [para. 2-2.3.3\(c\)](#)].

should: "should" or "it is recommended" is used to indicate that a provision is not mandatory but recommended as good practice.

*stiffness factor*⁴: the measurement of a pipe's ability to resist deflection, as determined in accordance with ASTM D2412.

**Example SG2.1
Committee Roster**

**ASME B31 COMMITTEE
Code for Pressure Piping**

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

STANDARDS COMMITTEE OFFICERS

W. H. Eskridge, Jr., *Chair*
K. A. Vilminot, *Vice Chair*
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Example SG2.2
Committee Roster: Variation

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(August 2019)

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Example SG2.3
SOC

ASME HST-3-2022 SUMMARY OF CHANGES

Following approval by the ASME HST Committee and ASME, and after public review, ASME HST-3-2022 was approved by the American National Standards Institute on March 31, 2022.

ASME HST-3-2022 includes the following changes identified by a margin note, **(22)**.

<i>Page</i>	<i>Location</i>	<i>Change</i>
1	Section 3-0.1	Former subpara. (d)(5) deleted and subsequent subparagraph redesignated and revised
1	Section 3-0.2	(1) Definitions of <i>load</i> , <i>qualified person</i> , <i>rated load</i> , <i>shall</i> , and <i>should</i> revised (2) Definition of <i>may</i> added
4	Figure 3-0.1-2	Title revised
5	Figure 3-0.1-3	Title revised
5	Figure 3-0.1-4	Title revised
5	Section 3-0.3	Updated
6	Section 3-0.4	Title revised and second paragraph added
7	Section 3-1.2	Last paragraph added
7	Section 3-1.5	Added
13	A-1.4	Updated
14	A-2.2	First paragraph revised
18	A-5.1	Subparagraph (a) revised
19	Nonmandatory Appendix B	Added

Example SG2.4
SOC With Record Numbers

ASME B16.51-2021

SUMMARY OF CHANGES

Following approval by the ASME B16 Standards Committee and ASME, and after public review, ASME B16.51-2021 was approved by the American National Standards Institute on November 12, 2021.

ASME B16.51-2021 includes the following changes identified by a margin note, **(21)**. The Record Numbers listed below are explained in more detail in the "List of Changes in Record Number Order" following this Summary of Changes.

<i>Page</i>	<i>Location</i>	<i>Change (Record Number)</i>
1	3.2	(1) First sentence editorially revised (2) Definition of <i>wrought</i> added (18-106)
2	6.1	In subpara. (b), first sentence revised (18-106)
2	6.3	Subparagraph (b) revised (18-1388)
15	Mandatory Appendix I	References updated (20-300)

Example SG2.5
LOC

LIST OF CHANGES IN RECORD NUMBER ORDER

Record Number	Change
17-1158	In Table 6.1-1C (former Table I-1), corrected minimum body wall thickness for NPS $\frac{3}{4}$, Class 3000, from 00.154 to 0.154. In Table 6.1-2 (former Table 2), corrected end-to-end couplet value for NPS 1 from 47.6 to 42.9 and weld ring diameter for NPS 1 from 42.9 to 33.4. In Table 6.1-5 (former Table 5), corrected end-to-end couplet value for NPS $\frac{3}{8}$ from 48 to 38; end-to-end cap value for NPS $\frac{3}{8}$, Class 3000, from 32 to 25; and weld ring diameter for NPS 3 from 114.3 to 88.9.
18-255	In Tables 6.1-1 and 6.1-1C (former Tables 1 and I-1), revised illustrations. In Table 6.1-2 (former Table 2), revised minimum socket wall thickness for NPS 2, Class 9000. In Table 6.1-4 (former Table 4), corrected cross-references in Notes (1) and (2). In Table 6.1-5 (former Table 5), revised illustration of boss; minimum length of thread, L_2, for NPS $1\frac{1}{4}$; and outside diameter couplet values for NPS 2 through 4, Class 6000. Corrected “End-to-End Couplet” and “Weld Ring Diameter” column headings. Corrected cross-reference in General Note (b). In Table 6.1-5C (former Table I-5), revised illustration of boss; outside diameter couplet value for NPS $\frac{1}{4}$, Class 3000; and Note (1). Corrected “End-to-End Couplet” column heading. Corrected cross-reference in General Note (b).
18-2628	Deleted para. 2.1.2 and Table 9. Redesignated para. 2.1.3 as 2.1.2.
21-622	Revised Table 1.1.1-1 (former Table 7) to properly align fittings with values. Deleted last sentence of para. 4.1. In Table 6.1-1C (former Table I-1), revised minimum socket depth and center-to-bottom of socket values. In Table 6.1-2C (former Table I-2), revised average socket wall thickness for NPS $\frac{1}{4}$, Class 3000; end-to-end couplet tolerances; weld ring diameters and tolerances; and weld ring lengths. In Table 6.1-5C (former Table I-5), revised outside diameter for NPS 3, Class 3000; weld ring diameters; General Notes (a) and (b); and Note (1).

Example SG2.6

Breakdowns With Lead-In Statements Requiring Colons

ASME PCC-1-2022

M-1.6 Material Application

Types 1 and 4 washer materials are intended for use with steel fasteners such as Grade 2H, 4, or 7 steel nuts per ASME SA-194. The Type 4 washer material is an alloy steel with a higher temperature limit. Types 5 and 6 washer materials are intended for use with austenitic steel fasteners such as Grade 8 austenitic steel nuts per ASME SA-194. The Type 6 washer material is a precipitation hardening stainless steel that has increased corrosion resistance as compared to Type 5 washer material. Type 7 washer material is intended for use with austenitic steel fasteners such as Grade 8 nuts per ASME SA-194 in low-temperature applications where other materials may become brittle. For the purposes of this Appendix, low-temperature applications refer to temperatures between -45°C (-50°F) and -185°C (-300°F).

M-1.7 Installation

To avoid any concerns about the effect of washer markings on the performance of the washer to nut interface, it is recommended that these washers be installed with the marked face toward the flange surface.

M-2 PURCHASE SPECIFICATION FOR THROUGH-HARDENED WASHERS

M-2.1 Scope

M-2.1.1 This Appendix covers the chemical, mechanical, and dimensional requirements for through-hardened steel washers for use with fasteners having nominal sizes of 14 mm to 100 mm and $\frac{1}{2}$ in. to 4 in. These washers are intended for use on pressure-containing flanges with bolts or studs and nuts. These washers are suitable for use with low-alloy steel and austenitic steel fasteners covered in ASME SA-193 and ASME SA-194.

M-2.1.2 The types of washers covered are

- (a) Type 1 — carbon steel
- (b) Type 4 — low-alloy steel
- (c) Type 5 — martensitic steel
- (d) Type 6 — precipitation hardening steel
- (e) Type 7 — austenitic steel

M-2.2 Ordering Information

Orders for washers under this specification shall include the following:

- (a) nominal size
- (b) type (see [para. M-2.1.2](#))
- (c) quantity (number of pieces)

M-2.3 Materials and Manufacture

M-2.3.1 Steel used in the manufacture of washers shall be produced by the open-hearth, basic-oxygen, or electric-furnace process.

M-2.3.2 Washers up to and including 100 mm (4 in.) nominal size shall be through-hardened, except Type 7 material.¹

M-2.3.3 Minimum tempering (precipitation) temperatures shall be as follows:

- (a) for Type 1, 205°C (400°F)
- (b) for Type 4, 370°C (700°F)
- (c) for Type 5, 425°C (800°F)
- (d) for Type 6, 550°C ($1,025^{\circ}\text{F}$)

M-2.4 Chemical Composition

Washers shall conform to the chemical composition specified in [Table M-2.4-1](#).

M-2.5 Mechanical Properties

Types 1, 4, and 5 washers shall have a hardness of 38 HRC to 45 HRC. Type 6 washers shall have a hardness of 33 HRC to 42 HRC. Type 7 washers shall have a hardness of 20 HRC to 23 HRC.

M-2.6 Dimensions and Tolerances

M-2.6.1 Washers shall conform to the dimensions shown in [Table M-2.6.1-1](#) or [Table M-2.6.1-2](#) with tolerances shown in [Table M-2.6.1-3](#) or [Table M-2.6.1-4](#) as applicable.

M-2.6.2 Washers shall have a multidirectional lay with a surface roughness not exceeding $3.2\text{ }\mu\text{m}$ ($125\text{ }\mu\text{in.}$) in height including any flaws in or on the surface. Surface roughness shall be as defined in ASME B46.1.

M-2.7 Workmanship, Finish, and Appearance

Washers shall be free of excess mill scale, excess coatings, and foreign material on bearing surfaces. Arc and gas cut washers shall be free of metal spatter.

M-2.8 Sampling and Number of Tests

M-2.8.1 A lot of washers shall consist of all material offered for inspection at one time that has the following common characteristics:

- (a) same nominal size
- (b) same material grade
- (c) same heat treatment

M-2.8.2 From each lot described in [para. M-2.8.1](#), the number of specimens tested for each required property shall be as specified in [Table M-2.8.2-1](#).

¹Type 7 material is an austenitic steel that does not harden through heat treatment. This alloy derives galling resistance through chemical composition rather than hardness.

Example SG2.7 Breakdown With Lead-In Statement Requiring a Period

ASME BPVC.VIII.1-2021

UG-80 – UG-82

(-3) at the midlength diameter,

$$L = L_e[2D_L/(D_L + D_s)]$$

$$D_o = 0.5(D_L + D_s)$$

(-4) at any cross section having an outside diameter of D_x ,

$$L = L_e(D_L/D_x)$$

$$D_o = D_x$$

(-c) for spheres, L is one-half of the outside diameter D_o .

(3) For cylinders and spheres, the value of t shall be determined as follows:

(-a) For vessels with butt joints, t is the nominal plate thickness less corrosion allowance.

(-b) For vessels with longitudinal lap joints, t is the nominal plate thickness and the permissible deviation is

$$t + e$$

(-c) Where the shell at any cross section is made of plates having different thicknesses, t is the nominal thickness of the thinnest plate less corrosion allowance.

(4) For cones and conical sections, the value of t shall be determined as in (3) above, except that t in (3)(-a), (3)(-b), and (3)(-c) shall be replaced by t_e as defined in UG-33(b).

(5) The requirements of (2) above shall be met in any plane normal to the axis of revolution for cylinders and cones and in the plane of any great circle for spheres. For cones and conical sections, a check shall be made at locations (2)(-b)(-1), (2)(-b)(-2), and (2)(-b)(-3) above and such other locations as may be necessary to satisfy manufacturers and inspectors that requirements are met.

(6) Measurements shall be taken on the surface of the base metal and not on welds or other raised parts of the material.

(7) The dimensions of a completed vessel may be brought within the requirements of this paragraph by any process which will not impair the strength of the material.

(8) Sharp bends and flat spots shall not be permitted unless provision is made for them in the design.

(9) If the nominal thickness of plate used for a cylindrical vessel exceeds the minimum thickness required by UG-28 for the external design pressure, and if such excess thickness is not required for corrosion allowance or loadings causing compressive forces, the maximum permissible deviation e determined for the nominal plate thickness used may be increased by the ratio of factor B

for the nominal plate thickness used divided by factor B for the minimum required plate thickness; and the chord length for measuring e_{max} shall be determined by D_o/t for the nominal plate thickness used.

(c) Vessels and components fabricated of pipe or tube under internal or external pressure may have permissible variations in diameter (measured outside) in accordance with those permitted under the specification covering its manufacture.

UG-81 TOLERANCE FOR FORMED HEADS

(a) The inner surface of a torispherical, toriconical, hemispherical, or ellipsoidal head shall not deviate outside of the specified shape by more than $1\frac{1}{4}\%$ of D nor inside the specified shape by more than $\frac{5}{8}\%$ of D , where D is the nominal inside diameter of the vessel shell at point of attachment. Such deviations shall be measured perpendicular to the specified shape and shall not be abrupt. The knuckle radius shall not be less than that specified.

(b) Hemispherical heads or any spherical portion of a torispherical or ellipsoidal head designed for external pressure shall, in addition to satisfying (a) above, meet the tolerances specified for spheres in UG-80(b) using a value of 0.5 for L/D_o .

(c) Measurements for determining the deviations specified in (a) above shall be taken from the surface of the base metal and not from welds.

(d) The skirts of heads shall be sufficiently true to round so that the difference between the maximum and minimum inside diameters shall not exceed 1% of the nominal diameter.

(e) When the skirt of any unstayed formed head is machined to make a driving fit into or over a shell, the thickness shall not be reduced to less than 90% of that required for a blank head (see UW-13) or the thickness of the shell at the point of attachment. When so machined, the transition from the machined thickness to the original thickness of the head shall not be abrupt but shall be tapered for a distance of at least three times the difference between the thicknesses.

UG-82 LUGS AND FITTING ATTACHMENTS

All lugs, brackets, saddle type nozzles, manhole frames, reinforcement around openings, and other appurtenances shall be formed and fitted to conform reasonably to the curvature of the shell or surface to which they are attached.

(a) When pressure parts, such as saddle type nozzles, manhole frames, and reinforcement around openings, extend over pressure-retaining welds, such welds shall be ground flush for the portion of the weld to be covered.

(b) When nonpressure parts, such as lugs, brackets, and support legs and saddles, extend over pressure-retaining welds, such welds shall be ground flush as described in (a) above, or such parts shall be notched or coped to clear those welds.

Example SG2.8 Breakdown With Lead-In Fragment

ASME B30.16-2022

(1) the various parts of the equipment, support system, and supporting structure will not be overstressed

(2) the stability of the equipment is not thereby endangered

(3) such side pulls will not cause the hoist rope to be pulled out of the sheave or across drum grooves

(4) such side pulls will not cause damage to the hoist

(l) The hoist shall not be used to lift loads in excess of the rated load of the hoist except during properly authorized tests or planned engineered lifts in accordance with [Section 16-3.5](#).

NOTE: Devices such as load cells, dynamometers, and scales may be used to determine the load to be lifted. Notify a qualified person before attempting to lift an unknown load.

(m) The hoist should not be used in any way that subjects it to shock loads.

(n) A load-limiting device shall not be used to measure the weight of the load.

(o) The hoist rope or chain shall be protected, so far as it is practical, from weld spatter or other damaging contaminants.

(p) Gloves that interfere with the operation of the controls shall not be worn.

(q) The harness or belt (when provided) shall be used with the wireless transmitter, or the transmitter shall be placed in the location intended for its support.

(r) The safety devices on the wireless transmitter shall not be overridden.

(s) The wireless transmitter shall be stored in a designated and protected location.

(t) The wireless transmitter shall be shut off when a power failure occurs.

(u) When two or more hoists are used to lift a single load, one designated person shall be in charge of the operation. This person shall analyze the operation and instruct all personnel involved in the proper positioning and rigging of the load and the movements to be made.

(v) The operator shall test the hoist brake(s) at the start of each shift for proper operation. This shall be done by lifting the load a few inches (centimeters) and applying the brake(s).

(w) The load shall not be lowered below the point where less than two wraps of rope remain on each hoisting drum unless a lower-limit device is provided, in which case no less than one wrap shall remain.

16-3.3.3 Responsibilities of Management (Owners/Users)

Management (owners/users) shall

(a) identify, document, and assign responsibilities of the hoist operator and other persons involved in the movement of the load(s) (see [paras. 16-3.3.2, 16-3.3.4, 16-3.3.5, and 16-3.3.6](#)).

(b) provide training or verify that persons who will operate the hoist have been trained.

(c) provide a written and practical examination that verifies that the person has acquired the knowledge and skill to properly operate the specific type of hoist that will be used. The examinations shall be defined by the owner/user and shall be in accordance with any local, state, and federal provisions that may apply.

(d) issue a certificate or formal record that verifies that the person has been trained and has passed the examinations required in (c).

(e) translate technical and safety-related information and manual(s). The entities responsible for the operation, use, inspection, testing, and maintenance of the covered equipment shall have the technical and safety-related information available in a language that their employees can read and understand. If the information is not available in a language understood by their employees, the entities shall obtain a translation of the original manufacturer's written safety information and manuals from the manufacturer or from a translation service provider. The translation(s) shall meet the requirements of [paras. 16-1.1.5\(c\) and 16-1.1.5\(d\)](#).

16-3.3.4 Responsibilities of Operators

(a) *Lifting/Lowering the Load*

(1) Three phases of lifting/lowering the load shall be addressed

(-a) before the lift (lifting/lowering)

(-b) during the lift (lifting/lowering)

(-c) after the lift (lifting/lowering)

(2) Rigging the load, attaching the load to the hook, and other tasks related to lifting/lowering the load may be performed by the hoist operator or by persons other than the hoist operator (see [para. 16-3.3.5](#)).

(3) Hoist operation may require the use of a signal-person(s) or other personnel who have responsibility for directing the lift/lower functions and shall be assigned prior to the lift (see [para. 16-3.3.6](#)).

(b) *Before the Lift (Lifting/Lowering)*. Operators shall

(1) be familiar with the applicable provisions of the equipment safety standards and the instructions listed in the manual(s) provided with the hoist.

(2) be familiar with controls, instructions, and product safety information located on the hoist.

(3) operate the hoist only when physically and otherwise fit.

(4) not energize the main switch or open the main valve if a warning sign, lock, or tag is on the device until the sign, lock, or tag is removed by the person who placed it on the device or by an authorized person.

(5) not remove a warning sign, lock, or tag that is on any device that controls power to the hoist, such as, but not limited to, the hoist disconnect, if the sign, lock, or tag was placed on the device by another person.

(6) place all controllers in the off position before closing the main line disconnect or opening the main valve.

Example SG2.9 Breakdown Items Requiring No End Punctuation

ASME PCC-1-2022

A-3 EXAMINATION PROGRAM

A-3.1 Academic Examination

Trainees at and above skill level 2 shall demonstrate their academic understanding and knowledge of health, safety, quality, and technical procedures relevant to the assembly of bolted joints by completion of a written or online assessment. A separate set of examination questions will be required for each supplemental endorsement and should cover the topics detailed in [paras. A-2.1 through A-2.5](#).

A-3.2 Practical Examination

Trainees at and above skill level 2 shall demonstrate their understanding of practical skills in the assembly of bolted joints by completing at least one bolted joint practical demonstration and witnessing the others (see [paras. A-3.3.1 through A-3.3.3](#)). The training of fundamentals demonstrations are designed to highlight significant aspects of the training curriculum and shall be performed in the presence of and to the satisfaction of the user and be administered and witnessed by a bolting trainer as defined in [para. A-1.3.5](#).

The training of fundamentals demonstrations detailed in [paras. A-3.3.1 through A-3.3.3](#) highlight several critical points of the joint assembly. The user may modify the demonstrations or substitute alternative demonstrations for specific joint types or gaskets, provided the bolting SME (see [para. A-1.3.6](#)) determines the desired learning points are still achieved.

A-3.3 Examples for Training of Fundamentals — Examination

A-3.3.1 Importance of Correct Pretightening Basic Skills. Perform the following on a flange test rig:

- (a) Select the correct gasket, bolt and nut material, and lubricant.
- (b) Install gasket, bolt and nut, and lubricant correctly.

A-3.3.2 Reaction of Different Types of Gaskets to Standard Tightening Procedure. Perform the following on a flange test rig having four or more bolts:

- (a) Assemble a four-bolt flange with a polytetrafluoroethylene (PTFE) sheet gasket, small-diameter flange with a spiral-wound gasket without inner and outer rings using a tightening pattern and ensure the gasket is centrally located on the raised face. Monitor the bolt load, stress, or elongation during the tightening to see when it stabilizes (number of passes).
- (b) Repeat (a) with a spiral-wound gasket with inner and outer rings.
- (c) Repeat (a) with a corrugated or grooved-metal gasket that has graphite facing.

A-3.3.3 Demonstration of the Effect of Lubricants. Perform the following:

- (a) Tighten a bolt using manual torque control with an instrumented bolt to measure the achieved bolt load.
- (b) Assemble a bolt without lubricant to a torque value.
- (c) Assemble the same bolt as in (b) with lubricant to the same torque value.
- (d) Compare the different achieved bolt loads.

A-3.4 Piping Endorsement — Examination

The practical examination for a piping endorsement requires the trainee to use a manual torque wrench to satisfactorily assemble one or more of the following types of flange joint:

- (a) raised-face flange
- (b) RTJ
- (c) flat-faced flange

A-3.5 Powered-Equipment Endorsement — Examination

A-3.5.1 Torque. The practical examination for a powered-equipment torque endorsement requires the trainee to use hydraulic, pneumatic, or electric-powered torque equipment to satisfactorily assemble flange joint types, including

- (a) raised-face flange
- (b) RTJ

A-3.5.2 Tension. The practical examination for a powered-equipment tension endorsement requires the trainee to use hydraulic bolt tensioning to satisfactorily assemble flange joint types, including

- (a) raised-face flange
- (b) RTJ

A-3.6 Heat Exchanger Endorsement — Examination

The practical examination for a heat exchanger endorsement requires the trainee to satisfactorily assemble either a simulated heat exchanger or a heat exchanger in the field under supervision. The exchanger joint configurations shall include

- (a) tubesheet to shell
- (b) bonnet or cover to tubesheet
- (c) collar bolt

A-3.7 Special Joint Endorsement — Examination

The practical examination for a special joint endorsement should cover joints or components that have a proprietary design, including, but not limited to, expansion joints, isolated joints, compact flanges, hub or clamp connectors, and rupture disks or spectacle disks.

The practical examination requires the trainee to satisfactorily assemble the specific special joint.

Key learning objectives should include

- (a) seal surface preparation
- (b) the importance of alignment and gap uniformity

Example SG2.10 Breakdown With Titles

ASME PCC-1-2022

PRESSURE BOUNDARY BOLTED FLANGE JOINT ASSEMBLY

1 SCOPE

This Standard covering bolted flange joint assemblies (BFJAs) applies to pressure-boundary flange joints with ring-type gaskets that are entirely within the circle enclosed by the bolt holes and with no contact outside this circle.¹ The principles of this Standard may be selectively applied to other joint geometries. By selecting those features suitable to the specific service or need, this Standard may be used to develop effective joint assembly procedures for the broad range of sizes and service conditions normally encountered in industry.

Users [see [para. 2\(b\)](#)] of this Standard are cautioned that the content contained in ASME PCC-1 has been developed generically and may not necessarily be suitable for all applications. Precautionary considerations are provided in some cases but should not be considered as all-inclusive. Sound engineering judgment and practices should be used to determine the applicability of a specific method or part of a method to a specific application. Each joint assembly procedure should be subject to an appropriate review by qualified personnel. While this Standard covers joint assembly within the scope of ASME Pressure Technology Codes and Standards, it may be used on equipment constructed in accordance with other codes and standards.

Guidance on troubleshooting BFJAs not providing leak-tight performance is also provided in this Standard (see [Nonmandatory Appendix P](#)).

2 INTRODUCTION

(a) *Intent.* A BFJA is a complex mechanical device; therefore, BFJAs that provide leak-free service result from many selections and activities having been made and performed within a relatively narrow band of acceptable limits. One of the activities essential to leak-free performance is the joint assembly process. The content outlined in this Standard covers the assembly elements essential for a high level of leak-tightness integrity of otherwise properly designed and constructed BFJAs. Users should develop written assembly procedures based on the owner's requirements, incorporating the

features contained herein that are deemed suitable to the specific application under consideration. Alternative features and methods for specific applications may be used subject to endorsement by the owner.

(b) *User.* The user is defined as any entity that applies the provisions of this Standard. The user could be the owner, owner's representative, manufacturer, fabricator, erector, or other contract personnel. The specific assignment of responsibilities among these entities is outside the scope of this Standard. As a result, this Standard is silent when assigning specific provisions to a single entity.

(c) *Owner and Representative.* Within the context of this Standard, "owner" and "representative" are defined as follows:

owner: the person, partnership, organization, or business responsible for the leak tightness of BFJAs on their pressure equipment.

representative: a person, partnership, organization, or business designated by the owner to carry out selected responsibilities on the owner's behalf.

(d) Responsibilities

(1) *Owner.* The owner is responsible for establishing the requirements for assembly, examination, inspection, and testing of BFJAs on their pressure equipment. The owner may designate a representative to carry out selected responsibilities in establishing such requirements; however, the owner retains ultimate responsibility for the actions of the representative.

NOTE: Within the context of this Standard, the term "owner" includes the owner and the owner's representative, as recorded in either the contract documents or the written assembly procedures [see [para. 13\(a\)](#)].

(2) *Assembler.* The assembler (see [Mandatory Appendix I](#)) of piping, pipelines, or equipment containing BFJAs is responsible for providing workmanship in conformance to the requirements of the assembly procedure.

(e) *Organization of This Standard.* The main body of this Standard covers the following topic areas associated with the BFJA assembly process:

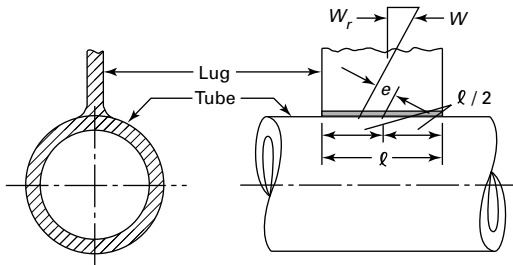
- (1) scope and introduction
- (2) training and qualification of bolted joint assembly personnel
- (3) cleaning of gasket seating surfaces of flanges

¹ Rules for the design of bolted flanges with ring-type gaskets are covered in ASME Boiler and Pressure Vessel Code (ASME BPVC), Section VIII, Division 1, Mandatory Appendix 2. See also ASME BPVC, Section VIII, Division 1, Nonmandatory Appendix S for supplementary considerations for bolted flanges that are helpful to the designer of Mandatory Appendix 2 flanges.

Example SG2.11 Steps

ASME BPVC.I-2021

Figure PG-56.1.2
Method of Computation of Attachments to Tubes



l = length of attachment of tube, in. (mm)

W = eccentric load applied to lug, lb (N)

W_r = load component normal to tube axis, lb (N)

In determining the allowable loading per unit length of attachment on a tube bend, the allowable unit load determined by using the outside diameter of the tube shall be increased by the amount of allowable compression or tension unit load, as applicable, for a tube having an outside diameter equivalent to the outside diameter of the bend and having a wall thickness the same as that of the tube bend (see Figure A-74). For an alternative method of determining the maximum allowable loading on structural attachments to tubes, see A-73.2 for conducting tests on full-size sections of tubes.

PG-56.2 Procedure for determining L_a in the equation in PG-56.1.1.

Step 1. Determine K from Table PG-56.2.

Step 2. Determine load factor, L_f , for compression or tension loading on lug from Figure PG-56.2, or from (a) or (b), when the range of the curves in Figure PG-56.2 does not extend far enough to cover specific cases.

(a) Compression Loading

$$L_f = 1.618X[-1.020 - 0.014 \log X + 0.005 (\log X)^2]$$

(b) Tension Loading

$$L_f = 49.937X[-2.978 + 0.898 \log X - 0.139 (\log X)^2]$$

Step 3. Determine available stress, S_t .

$$S_t = 2.0 S_a - S$$

Step 4. Using values obtained in Steps 1 through 3, determine maximum allowable unit load, L_a .

$$L_a = Kb(L_f)S_t$$

where

D = outside diameter of tube, in. (mm)

K = tube attachment width design factor from Table PG-56.2, dimensionless

L_f = a compression or tension load factor, dimensionless

$\log$ = logarithm to base 10

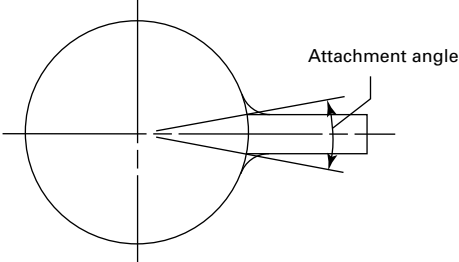
S = pressure stress in tube determined by the equation in PG-27.2.1, psi (MPa)

S_a = allowable stress value from Section II, Part D, Subpart 1, Table 1A, psi (MPa)

S_t = portion of allowable stress available for attachment loading, from Step 3, psi (MPa)

t = tube wall thickness, in. (mm)

Table PG-56.2
Tube Attachment Angle Design Factor, K

										
Angle of attachment, deg	0	5	10	15	20	25	30	35	40	45
Design factor, K	1.000	1.049	1.108	1.162	1.224	1.290	1.364	1.451	1.545	1.615
Angle of attachment, deg	50	55	60	65	70	75	80	85	90	...
Design factor, K	1.730	1.836	1.949	2.076	2.221	2.341	2.513	2.653	2.876	...

Example SG2.12

Full Definition vs. Cross-Referenced Definition

ASME BPVC.X-2021

Tension stresses are considered positive and compression stresses are considered negative.

stress-strain relationship: a linear relation is usually assumed for calculating stress from strain or strain from stress. For multidirectional laminates, it can be generalized to include in-plane stress-strain and flexural stress-strain relations. All anisotropic relations are simple extensions of the isotropic relation. Young's modulus is the quotient of stress divided by strain.

surface mat: a very thin mat, usually 7 mils (0.18 mm) to 20 mils (0.51 mm) thick, or highly filamentized fiber.

surface treatment: on fibers, the compounds which, when applied to filaments at forming, provide a loose bond between the filaments, and provide various desired handling and processing properties. For reinforcing plastics, the surface treatment will also contain a coupling agent. Also called *sizing*.

symmetric laminate: possessing midplane symmetry.

tack: with special reference to prepreg materials, the degree of stickiness of the resin.

thermal stress: a self-balancing stress produced by a nonuniform distribution of temperature or by differing thermal coefficients of expansion. Thermal stress is developed in a solid body whenever a volume of material is prevented from assuming the size and shape that it normally would under a change in temperature.

Two types of thermal stress are recognized, depending on the volume or area in which distortion takes place, as follows:

(a) general thermal stress, which is associated with distortion of the structure in which it occurs. Examples of general thermal stress are

(1) stress produced by an axial temperature distribution in a cylindrical shell

(2) stress produced by the temperature difference between a nozzle and the shell to which it is attached

(b) local thermal stress, which is associated with almost complete suppression of the differential expansion and thus produces no significant distortion. Examples of local thermal stress are

(1) stress in a small hot spot in a vessel wall

(2) thermal stress in layers of material which have different coefficients of expansion

thermoplastic: a plastic which is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

thermoset: a plastic which, when cured by application of heat or chemical means, changes into a substantially infusible and insoluble material.

thixotropic: the capacity of a liquid material to have high static shear strength (viscosity) and at the same time low dynamic shear strength. Such a material can be mixed (stirred), but will not flow under the force of gravity.

tow: an untwisted group of continuous fibers (see *roving*)

transformation: variation of stiffness, strength, stress, strain, and other material properties due to the coordinate transformation or rotation of the reference coordinate axes. Transformation follows strict mathematical equations. The study of composite materials relies heavily on these transformation equations to correctly describe the directional dependency of the materials.

uniaxial load: a loading condition whereby a laminate is stressed in only one direction.

unidirectional composite: having parallel fibers in a composite. Compare with *unidirectional laminate*.

unidirectional laminate: a composite laminate in which all the fibers are oriented in the same direction.

veil: see *surface mat*.

vinyl ester: a thermoset resin with epoxy backbone, but which cures by peroxide initiation like a polyester.

voids: air pockets that have been trapped and cured into a laminate.

volatiles: materials in a roving sizing or a resin formulation which are capable of being driven off as a vapor at room or slightly elevated temperature.

wall stress: in a filament-wound part, usually a pressure vessel, the stress calculated using the load and the entire laminate cross-sectional area (see also *fiber stress*).

waywind: the number of wraps or turns that roving or yarn make from one side of the wound package back to the same side.

wet lay-up: a reinforced plastic which has liquid resin applied as the reinforcement is being laid up.

wet-out: the condition of an impregnated roving or yarn wherein substantially all voids between sized strands and filaments are filled with resin.

wet-out rate: the time required for a plastic to fill the interstices of a reinforcement material and wet the surface of the reinforcement fibers, usually determined by optical or light transmission means.

wet winding: filament-winding reinforced plastics when the fiber reinforcement is coated with liquid resin just prior to wrapping on the mandrel.

winding pattern: the path of the fiber laid down by the winding machine, generally repeated within a layer, leading to the eventual complete coverage of the liner or mandrel. The term also applies to nonrepeating paths such as transitions between layers wound at different helical angles.

winding tension: in filament winding, the amount of tension on the reinforcement as it makes contact with a mandrel.

yardage: see *yield*.

Example SG2.13

Single-Phrase vs. Multisentence Definitions

ASME BPVC.X-2021

Tension stresses are considered positive and compression stresses are considered negative.

stress-strain relationship: a linear relation is usually assumed for calculating stress from strain or strain from stress. For multidirectional laminates, it can be generalized to include in-plane stress-strain and flexural stress-strain relations. All anisotropic relations are simple extensions of the isotropic relation. Young's modulus is the quotient of stress divided by strain.

surface mat: a very thin mat, usually 7 mils (0.18 mm) to 20 mils (0.51 mm) thick, or highly filamentized fiber.

surface treatment: on fibers, the compounds which, when applied to filaments at forming, provide a loose bond between the filaments, and provide various desired handling and processing properties. For reinforcing plastics, the surface treatment will also contain a coupling agent. Also called *sizing*.

symmetric laminate: possessing midplane symmetry.

tack: with special reference to prepreg materials, the degree of stickiness of the resin.

thermal stress: a self-balancing stress produced by a nonuniform distribution of temperature or by differing thermal coefficients of expansion. Thermal stress is developed in a solid body whenever a volume of material is prevented from assuming the size and shape that it normally would under a change in temperature.

Two types of thermal stress are recognized, depending on the volume or area in which distortion takes place, as follows:

(a) general thermal stress, which is associated with distortion of the structure in which it occurs. Examples of general thermal stress are

(1) stress produced by an axial temperature distribution in a cylindrical shell

(2) stress produced by the temperature difference between a nozzle and the shell to which it is attached

(b) local thermal stress, which is associated with almost complete suppression of the differential expansion and thus produces no significant distortion. Examples of local thermal stress are

(1) stress in a small hot spot in a vessel wall

(2) thermal stress in layers of material which have different coefficients of expansion

thermoplastic: a plastic which is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

thermoset: a plastic which, when cured by application of heat or chemical means, changes into a substantially infusible and insoluble material.

thixotropic: the capacity of a liquid material to have high static shear strength (viscosity) and at the same time low dynamic shear strength. Such a material can be mixed (stirred), but will not flow under the force of gravity.

tow: an untwisted group of continuous fibers (see *roving*).

transformation: variation of stiffness, strength, stress, strain, and other material properties due to the coordinate transformation or rotation of the reference coordinate axes. Transformation follows strict mathematical equations. The study of composite materials relies heavily on these transformation equations to correctly describe the directional dependency of the materials.

uniaxial load: a loading condition whereby a laminate is stressed in only one direction.

unidirectional composite: having parallel fibers in a composite. Compare with *unidirectional laminate*.

unidirectional laminate: a composite laminate in which all the fibers are oriented in the same direction.

veil: see *surface mat*.

vinyl ester: a thermoset resin with epoxy backbone, but which cures by peroxide initiation like a polyester.

voids: air pockets that have been trapped and cured into a laminate.

volatiles: materials in a roving sizing or a resin formulation which are capable of being driven off as a vapor at room or slightly elevated temperature.

wall stress: in a filament-wound part, usually a pressure vessel, the stress calculated using the load and the entire laminate cross-sectional area (see also *fiber stress*).

waywind: the number of wraps or turns that roving or yarn make from one side of the wound package back to the same side.

wet lay-up: a reinforced plastic which has liquid resin applied as the reinforcement is being laid up.

wet-out: the condition of an impregnated roving or yarn wherein substantially all voids between sized strands and filaments are filled with resin.

wet-out rate: the time required for a plastic to fill the interstices of a reinforcement material and wet the surface of the reinforcement fibers, usually determined by optical or light transmission means.

wet winding: filament-winding reinforced plastics when the fiber reinforcement is coated with liquid resin just prior to wrapping on the mandrel.

winding pattern: the path of the fiber laid down by the winding machine, generally repeated within a layer, leading to the eventual complete coverage of the liner or mandrel. The term also applies to nonrepeating paths such as transitions between layers wound at different helical angles.

winding tension: in filament winding, the amount of tension on the reinforcement as it makes contact with a mandrel.

yardage: see *yield*.

Example SG2.14

Single Term With Multiple Definitions

ASME NM.1-2020

stress is that it is self-limiting. Local yielding and minor distortions can satisfy the displacement or expansion conditions that cause the stress to occur. Failure from one application of the stress is not to be expected. Further, the displacement stresses calculated in this Standard are “effective” stresses and are generally lower than those predicted by theory or measured in strain-gauge tests.¹

hydrostatic design basis (HDB): selected properties of plastic piping materials to be used in accordance with ASTM D2837 to determine the hydrostatic design stress (see definition below) for the material.

hydrostatic design stress (HDS): the maximum continuous stress due to internal pressure to be used in the design of plastic piping, determined from the hydrostatic design basis by use of a service (design) factor.

sustained stress: a stress developed by an imposed loading that is necessary to satisfy the laws of equilibrium between external and internal forces and moments. The basic characteristic of a sustained stress is that it is not self-limiting. If a sustained stress exceeds the yield strength of the material through the entire thickness, the prevention of failure is entirely dependent on the strain-hardening properties of the material. A thermal stress is not classified as a sustained stress. Further, the sustained stresses calculated in this Standard are “effective” stresses and are generally lower than those predicted by theory or measured in strain-gauge tests.

tensile test: a method used to determine the overall strength of a given object by fitting the object between two grips, one at each end, then slowly pulling the grips in opposite directions until the object breaks. This method provides information related to the object’s yield point, tensile strength, and ultimate strength.

thermoplastic: a plastic (polymer) that is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

thermosetting plastic: a resin and catalyst (polymer) capable of being changed into a substantially infusible or insoluble product when cured at room temperature, or by application of heat, or by chemical means.

tube or tubing: see *pipe*.

ultrasonic examination: a nondestructive method of evaluating or testing materials by introducing ultrasonic waves into, through, or onto the surface of the article

being examined and determining various attributes of the material from effects on the ultrasonic waves. Also known as ultrasonic testing (UT).

vent: a small opening that allows air, gas, or the like to escape piping systems or a closed space. In thermoplastic-lined metal piping, it is the method of relieving pressure between the liner and the housing caused by permeation.

vent coupling: an accessory added to the vent hole to enable ducting of permeates.

virgin plastic: a plastic (polymer) material in the form of pellets, granules, powder, floc, or liquid that has not been subjected to use or processing other than that required for its initial manufacture.

visual examination: the observation of the portion of components, joints, and other piping elements that are or can be exposed to view before, during, or after manufacture, fabrication, assembly, erection, examination, or testing.

Welding Procedure Specification (WPS):

(a) formal written document describing the process for joining thermoplastic piping components by fusion, which provides direction to the installer or fusion machine operator for making sound and quality production fusion joints. See also *Fusion Performance Qualification (FPQ)* and *Joining Procedure Specification (JPS)*.

(b) formal written document that lists the parameters to be used in construction of weldments in accordance with requirements of the ASME B31 Pressure Piping Code Sections, various ASME BPVC Sections, and AWS B2.4.

1-4 ABBREVIATIONS

Unless otherwise noted, the abbreviations defined in Table 1-4-1 are used in this Standard to replace lengthy phrases in the text and in the titles of standards in Table 4-2.1-1.

1-5 STATUS OF APPENDICES

Table 1-5-1 indicates for each Appendix of this Standard whether it contains requirements or guidance. See the first page of each Appendix for details.

¹ Normally, the most significant displacement stress is encountered in the thermal expansion stress range from ambient to the normal operating condition. This stress range is also the stress range usually considered in a flexibility analysis. However, if other significant stress ranges occur, whether they are displacement stress ranges (such as from other thermal expansion or contraction events, or differential support movements) or sustained stress ranges (such as from cyclic pressure, steam hammer, or earthquake inertia forces), paras. 2-2.3.3(b) and 2-3.3.1.3 may be used to evaluate their effect on fatigue life.

Example SG2.15 Breakdown Within a Definition

ASME BPVC.X-2021

Tension stresses are considered positive and compression stresses are considered negative.

stress-strain relationship: a linear relation is usually assumed for calculating stress from strain or strain from stress. For multidirectional laminates, it can be generalized to include in-plane stress-strain and flexural stress-strain relations. All anisotropic relations are simple extensions of the isotropic relation. Young's modulus is the quotient of stress divided by strain.

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surface treatment: on fibers, the compounds which, when applied to filaments at forming, provide a loose bond between the filaments, and provide various desired handling and processing properties. For reinforcing plastics, the surface treatment will also contain a coupling agent. Also called *sizing*.

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thermoplastic: a plastic which is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

thermoset: a plastic which, when cured by application of heat or chemical means, changes into a substantially infusible and insoluble material.

thixotropic: the capacity of a liquid material to have high static shear strength (viscosity) and at the same time low dynamic shear strength. Such a material can be mixed (stirred), but will not flow under the force of gravity.

tow: an untwisted group of continuous fibers (see *roving*).

transformation: variation of stiffness, strength, stress, strain, and other material properties due to the coordinate transformation or rotation of the reference coordinate axes. Transformation follows strict mathematical equations. The study of composite materials relies heavily on these transformation equations to correctly describe the directional dependency of the materials.

uniaxial load: a loading condition whereby a laminate is stressed in only one direction.

unidirectional composite: having parallel fibers in a composite. Compare with *unidirectional laminate*.

unidirectional laminate: a composite laminate in which all the fibers are oriented in the same direction.

veil: see *surface mat*.

vinyl ester: a thermoset resin with epoxy backbone, but which cures by peroxide initiation like a polyester.

voids: air pockets that have been trapped and cured into a laminate.

volatiles: materials in a roving sizing or a resin formulation which are capable of being driven off as a vapor at room or slightly elevated temperature.

wall stress: in a filament-wound part, usually a pressure vessel, the stress calculated using the load and the entire laminate cross-sectional area (see also *fiber stress*).

waywind: the number of wraps or turns that roving or yarn make from one side of the wound package back to the same side.

wet lay-up: a reinforced plastic which has liquid resin applied as the reinforcement is being laid up.

wet-out: the condition of an impregnated roving or yarn wherein substantially all voids between sized strands and filaments are filled with resin.

wet-out rate: the time required for a plastic to fill the interstices of a reinforcement material and wet the surface of the reinforcement fibers, usually determined by optical or light transmission means.

wet winding: filament-winding reinforced plastics when the fiber reinforcement is coated with liquid resin just prior to wrapping on the mandrel.

winding pattern: the path of the fiber laid down by the winding machine, generally repeated within a layer, leading to the eventual complete coverage of the liner or mandrel. The term also applies to nonrepeating paths such as transitions between layers wound at different helical angles.

winding tension: in filament winding, the amount of tension on the reinforcement as it makes contact with a mandrel.

yardage: see *yield*.

Example SG2.16 Synonyms Within a Definitions List

ASME NM.1-2020

Category M fluid service: a fluid service in which both of the following apply:

(a) The fluid is so highly toxic that a single exposure to a very small quantity of the fluid, caused by leakage, can produce serious irreversible harm to persons on breathing or bodily contact, even when prompt restorative measures are taken.

(b) After consideration of piping design, experience, service conditions, and location, the owner determines that the requirements for normal fluid service do not sufficiently provide the leak tightness required to protect personnel from exposure.

normal fluid service: a fluid service not subject to the requirements for Category D or Category M fluid service.

fusing: a permanent bond between thermoplastic piping components formed by heating the parts sufficiently to permit the commingling of the materials when the parts are pressed together. Also called *fusion*.

fusing machine operator: person who uses and controls the equipment (including manual, semiautomatic, and automatic machine styles) required to fuse thermoplastic piping components together. The fusing processes included are butt fusing, heated-tool butt welding, infrared welding, flow-fusion welding, socket fusion, socket-fusion welding, saddle fusion, electrofusion, electrofusion welding, and electrofusion saddle joining or welding.

Fusing Procedure Specification (FPS): a formal written document describing the process for joining thermoplastic piping components by fusion, which provides direction to the installer or fusion machine operator for making sound and quality production fusion joints. See also *Joining Procedure Specification (JPS)* and *Procedure Qualification Record (PQR)*.

Fusion Performance Qualification (FPQ): a document that is intended to verify the ability of the fusing machine operator to produce a sound, fused joint when following a qualified Fusing Procedure Specification (FPS). See also *Performance Qualification Test Record (PQTR)*.

grounding lug: a connecting device to enable electrical continuity between metallic components of a thermoplastic-lined metallic piping system.

heat fusion: a permanent bond between thermoplastic piping components formed by heating the parts sufficiently to permit the commingling of the materials when the parts are pressed together.

heat joint: see *heat fusion*.

high-speed tensile impact test: a method used to evaluate the mechanical properties of thermoplastic pipe (polyethylene and others) joined by heat fusing, in which a test sample under tension is exposed to a defined impact load.

high-vapor-pressure application: a liquid-pipeline end use in which the media transported are hydrocarbon liquids having a vapor pressure greater than 110 kPa (16 psi) absolute at 38°C (100°F), as determined by ASTM D323.

hot oiling: the activity of passing oil at an elevated temperature into a piping system for the purpose of removing paraffin and wax deposits from the pipe bore.

hydrostatic design basis (HDB): see *stress*.

hydrostatic design stress (HDS): see *stress*.

hydrostatic test: an evaluation procedure in which water is used as the medium to determine the pressure containment capabilities of a piping system or component. Also called *hydrotest*.

imperfection: a condition of not being perfect; a departure of a quality characteristic from its intended condition.

inspection: the act of witnessing or verifying compliance to the specified requirements.

Inspector: a person who witnesses or verifies compliance to the specified requirements.

installer: person who performs the solvent weld, makes flange connections, or assembles other types of mechanical connections.

Joining Procedure Specification (JPS): general term for the documented procedure for all types of thermoplastic joining processes.

joint crush test: a method used to evaluate socket-fused or electrofused thermoplastic joints.

joint design: the joint geometry together with the required dimensions of the welded or heat-fused joint.

lap joint: a type of mechanical connection made between piping components using a flange adapter with a backup ring. Flared steel pipe with a thermoplastic liner can also be used.

listed: for the purposes of this Standard, a term describing a material that conforms to one or more specifications in ASME NM.3.1, or as defined in this Standard, or to the extent as referenced in the standards in Table 4-2.1-1.

long-term hydrostatic strength (LTHS): the estimated hoop stress, expressed in megapascals (pressure per square inch), in a plastic pipe wall that will cause failure of the pipe at an average of 100 000 h when subjected to a constant hydrostatic pressure.

material: a substance from which a component is made. Materials include, but are not limited to, thermoplastics, thermoset plastics, metal alloys, elastomers, reinforcing fibers, and thermoplastic fibers.

maximum allowable operating pressure (MAOP): the highest continuous internal pressure at which a piping system may be operated in accordance with the provisions of this Standard.

Example SG2.17 Subterms Within a Definitions List

ASME B30.30-2019

Chapter 30-0 Scope, Definitions, Personnel Competence, Translations, and References

SECTION 30-0.1: SCOPE OF ASME B30.30

Volume B30.30 includes provisions that apply to the construction, selection, installation, attachment, testing, inspection, maintenance, repair, use, and replacement of wire rope, hybrid rope, and synthetic fiber rope and rope-lifting components used in conjunction with equipment addressed in the volumes of the ASME B30 Standard. These provisions apply to a particular volume when B30.30 is referenced and as specified in that volume.

SECTION 30-0.2: DEFINITIONS

aramid fiber: a manufactured, high modulus fiber made from a long-chain synthetic aromatic polyamide in which at least 85% of the amide linkages join two aromatic rings.

birdcage: a rope condition that results in deformation with the outer strands being displaced away from the rope axis. It is usually the result of shock loading or localized twisting in a rope (see [Figure 30-0.2-1](#)).

braid: a rope or textile structure formed by intertwining strands.

double braid: a rope constructed from an inner hollow braided rope (core) surrounded by another hollow braided rope (cover) (also called *braid-on-braid* or *two-in-one braid*).

single braid: rope structure consisting of multiple strands that may be intertwined in a plain or twill pattern.

crown break: a wire break located on the outside of the rope that occurs above the strand-to-strand contact points with both ends visible (see [Figure 30-0.2-2](#)).

D/d ratio: the ratio of the pitch diameter of the sheave or drum, *D*, to the nominal rope diameter, *d* (see [Figure 30-0.2-3](#)).

denier: a mass-per-unit-length measure equal to the weight in grams of 9 000 m of the material. Denier is a direct numbering system in which the lower numbers represent the finer sizes and the higher numbers the coarser sizes.

design factor: the minimum breaking force of the rope in a rope system divided by the maximum static tension in the rope.

dogleg, minor: a bend or deformation exhibiting no associated strand distortion and that cannot be observed while the rope is under tension.

dogleg, severe: a permanent, localized, irreparable bend or deformation in a wire rope that restricts the natural adjustment of the rope's components during operation due to strand distortion. It is caused by improper use or handling and results in an indeterminate loss of strength in the rope (see [Figure 30-0.2-4](#)).

fiber core: a wire rope center component consisting of man-made or natural (vegetable) materials whose purpose is to support the outer strands of the wire rope and is not included as one of the load-bearing components of the wire rope when calculating the minimum breaking force.

fleet angle: the angle between the rope's position on a drum or sheave and the line drawn perpendicular to the axis of the drum or sheave through the center of the nearest fixed sheave (see [Figure 30-0.2-5](#)).

groove corrugation: a repetitive pattern in the groove of a sheave or drum caused by wear at the contact point with each rope strand that may cause rope wear and distortion.

guy: a fixed length of strand or rope for stabilizing or maintaining a structure in a fixed position or a constant distance between the two components connected by the rope.

heavy rope service: service that involves operating at 85% to 100% of rope rated load or in excess of ten lift cycles per hour as a regular specified procedure.

high modulus polyethylene (HMPE): a polyolefin fiber produced by gel spinning or solid-state extrusion of an ultra-high-molecular-weight polyethylene (UHMWPE) feedstock to produce extremely high tenacity [also known as extended-chain polyethylene (ECPE) or high-performance polyethylene (HPPE)].

hours of rope operation: the actual or estimated operating time of the rope.

hybrid rope: a wire rope consisting of both synthetic and steel components. The synthetic components are included as load-bearing components of the rope when calculating its minimum breaking force.

Example SG2.18 Single In-Text Note

ASME B30.30-2019

Chapter 30-1 Steel Wire Rope

SECTION 30-1.1: SCOPE

Chapter 30-1 includes provisions that apply to wire rope.

SECTION 30-1.2: TRAINING

Users of wire rope shall be trained, as applicable, in the use, selection, inspection, installation, maintenance, attachment, replacement, and effects of environment as covered by this Chapter.

SECTION 30-1.3: TYPES OF STEEL WIRE ROPE

30-1.3.1 Standard Wire Rope

Standard wire rope is a wire rope that has one of the following:

- (a) a steel core rope, WSC, or IWRC that has the same direction of lay as the wire rope in which it is used
- (b) a non-load-bearing fiber core
- (c) no core
- (d) load-bearing synthetic fibers in the strands, the core, or both (also known as a hybrid rope)

NOTE: Low-torque rope is considered standard wire rope.

30-1.3.2 Rotation-Resistant Wire Rope

Rotation-resistant wire rope is rope designed to generate reduced levels of torque and rotation when loaded and comprising an assembly of two or more layers of strands laid helically around a center, the direction of lay of the outer strands being opposite to that of the underlying layer. There are three categories of rotation-resistant rope. The applicable rotation resistance categories shall be identified by the rope manufacturer on the wire rope certificate as follows (see para. 30-1.5.5):

- (a) Category 1: a wire rope constructed in such a manner that it displays little or no tendency to rotate and has at least 15 outer strands.
- (b) Category 2: a wire rope constructed in such a manner that it has significant resistance to rotation and has at least ten outer strands.
- (c) Category 3: a wire rope constructed in such a manner that it has limited resistance to rotation and has no more than nine outer strands.

SECTION 30-1.4: ROPE SELECTION, MINIMUM BREAKING FORCE, DESIGN FACTORS, AND OTHER REQUIREMENTS

30-1.4.1 Selection

The wire rope shall be selected by the LHE manufacturer, the rope manufacturer, or a qualified person.

30-1.4.2 Selection Limitations

- (a) Wire rope with fiber core shall not be used for boom hoist or luffing attachment reeving.

NOTE: This does not preclude the use of hybrid rope.

- (b) Category 2 and 3 rotation-resistant rope shall not be used on single-layer drums unless approved by the LHE manufacturer or a qualified person.

- (c) Rotation-resistant rope and fiber core rope shall not be used for the following:

- (1) boom support, boom hoist, or boom extension system rope, except as noted in (e)
- (2) boom support or boom hoist rope during erection, except as noted in (e)
- (3) standing rope that is used as live rope during erection
- (d) Rotation-resistant wire rope shall not be used for hoisting on ASME B30.14 LHE.

- (e) Rotation-resistant rope may be used as boom hoist reeving when load hoists are used as boom hoists for attachments, such as luffing attachments or boom and mast attachment systems. Under these conditions, the following requirements shall be met:

- (1) The load hoist drum being used as a boom hoist shall have a first-layer rope pitch diameter of not less than 18 times the nominal diameter of the rope used.
- (2) All sheaves used in the boom hoist reeving system shall have a rope pitch diameter of not less than 18 times the nominal diameter of the rope used.
- (3) The design factor shall be the total minimum breaking force of all parts of rope in the system divided by the load imposed on the rope system when supporting the static weights of the structure and the crane rated load.
- (4) The frequency of inspection of the wire rope shall be increased when using rotation-resistant rope in boom hoist or luffing attachment service.

Example SG2.19 Multiple In-Text Notes

ASME NM.2-2020

helical winding: filament winding where the reinforcement is placed at a specified angle (other than 0 deg or 90 deg) to the axis of rotation.

interior layer: resin-rich layer that is between the surfacing veil and the structural layers of a reinforced plastic laminate.

polyester: resin produced by the polycondensation of dihydroxy glycols and dibasic organic acids or anhydrides, where at least one component contributes ethylenic unsaturation, yielding resins that can react with styrol monomers to give highly cross-linked thermoset copolymers.

structural layer: the portion of the laminate construction providing the primary mechanical strength.

surfacing veil: a thin mat of fine fibers used primarily to produce a smooth, corrosion-resistant, resin-rich surface on a reinforced plastic laminate.

vinyl ester: resin characterized by reactive unsaturation located predominately in terminal positions that can react with styrol monomers to give highly cross-linked thermoset copolymers.

IV-5 MATERIALS AND MANUFACTURE

IV-5.1 Resin System

IV-5.1.1 Resin

(a) The resin used shall be a commercial-grade, corrosion-resistant polyester that has been determined to be acceptable for the service by either test (see ASTM C581) or previous documented service.

(b) Where service conditions have not been evaluated, a suitable resin may also be selected by agreement between the manufacturer and the purchaser.

(c) The use of one resin in the corrosion barrier and a different resin in the structural layer (see [section IV-7](#)) is permitted if acceptable to the purchaser.

IV-5.1.2 Additives

(a) Additives such as thixotropic agents or flame retardants may be used when agreed upon by both the manufacturer and the purchaser.

(b) Additional styrene may be added to the resin for viscosity control.

(c) No material shall be added to the resin used in the filament winding for the sole purpose of changing the color or translucency of the resin.

NOTES:

- (1) The addition of flame retardants and thixotropic agents can affect laminate properties and visual inspection of laminate quality.

- (2) The catalyst/promoter system, diluents, flame retardants, or thixotropic agents used in the resin can affect its chemical resistance.
- (3) Antimony compounds or other fire-retardant agents may be added to halogenated resins for improved fire resistance, if agreed to by the manufacturer and the purchaser. These compounds usually impact the translucency of the resin and do not improve the flame retardancy of nonhalogenated resins.

IV-5.1.3 Additives for Abrasion Resistance

(a) Additives may be added to the interior and/or exterior corrosion barrier to increase abrasion resistance as agreed upon between the manufacturer and the purchaser.

(b) Additives to enhance abrasion resistance may be added to the resin, up to 5% by weight of the resin system in the filament winding, without impacting allowable stresses per ASME NM.3.3.

IV-5.2 Fiber Reinforcements

IV-5.2.1 Surfacing Veil

(a) The surfacing veil used in a laminate shall be a chemical-resistant glass or organic fiber determined to be acceptable for the chemical service by either ASTM C581 or verified case history.

(b) The surfacing veil shall be a minimum of 0.254 mm (10 mils) in dry thickness.

IV-5.2.2 Chopped-Strand Reinforcements

(a) Chopped-strand reinforcements shall be E-type or E-CR-type glass fibers 25 mm to 50 mm (1 in. to 2 in.) long, applied in a uniform layer with random orientation.

(b) The fibers shall have a sizing compatible with the selected resin.

(c) Chopped-strand reinforcements may be applied as a mat or as continuous strand roving that is chopped into short lengths and sprayed onto the laminate in a process known as "spray up." Either form is most commonly applied in layers weighing 460 g/m² (1.5 oz/ft²), although other weights are available and may be used.

IV-5.2.3 Continuous Roving

(a) Continuous roving shall be E-type or E-CR-type glass roving, with a maximum 4 400 tex (minimum yield of 110 yd/lb).

(b) The sizing on the roving shall be compatible with the resin.

IV-6 LAMINATES

IV-6.1 Laminate Construction

The pipe wall shall consist of a corrosion barrier (comprising an inner surface and interior layer), a structural layer, and an outer surface.

Example SG2.20
Footnotes in Front Matter

(21)

FOREWORD*

In 1911, The American Society of Mechanical Engineers established the Boiler and Pressure Vessel Committee to formulate standard rules for the construction of steam boilers and other pressure vessels. In 2009, the Boiler and Pressure Vessel Committee was superseded by the following committees:

- (a) Committee on Power Boilers (I)
- (b) Committee on Materials (II)
- (c) Committee on Construction of Nuclear Facility Components (III)
- (d) Committee on Heating Boilers (IV)
- (e) Committee on Nondestructive Examination (V)
- (f) Committee on Pressure Vessels (VIII)
- (g) Committee on Welding, Brazing, and Fusing (IX)
- (h) Committee on Fiber-Reinforced Plastic Pressure Vessels (X)
- (i) Committee on Nuclear Inservice Inspection (XI)
- (j) Committee on Transport Tanks (XII)
- (k) Committee on Overpressure Protection (XIII)
- (l) Technical Oversight Management Committee (TOMC)

Where reference is made to “the Committee” in this Foreword, each of these committees is included individually and collectively.

The Committee’s function is to establish rules of safety relating to pressure integrity, which govern the construction** of boilers, pressure vessels, transport tanks, and nuclear components, and the inservice inspection of nuclear components and transport tanks. The Committee also interprets these rules when questions arise regarding their intent. The technical consistency of the Sections of the Code and coordination of standards development activities of the Committees is supported and guided by the Technical Oversight Management Committee. This Code does not address other safety issues relating to the construction of boilers, pressure vessels, transport tanks, or nuclear components, or the inservice inspection of nuclear components or transport tanks. Users of the Code should refer to the pertinent codes, standards, laws, regulations, or other relevant documents for safety issues other than those relating to pressure integrity. Except for Sections XI and XII, and with a few other exceptions, the rules do not, of practical necessity, reflect the likelihood and consequences of deterioration in service related to specific service fluids or external operating environments. In formulating the rules, the Committee considers the needs of users, manufacturers, and inspectors of pressure vessels. The objective of the rules is to afford reasonably certain protection of life and property, and to provide a margin for deterioration in service to give a reasonably long, safe period of usefulness. Advancements in design and materials and evidence of experience have been recognized.

This Code contains mandatory requirements, specific prohibitions, and nonmandatory guidance for construction activities and inservice inspection and testing activities. The Code does not address all aspects of these activities and those aspects that are not specifically addressed should not be considered prohibited. The Code is not a handbook and cannot replace education, experience, and the use of engineering judgment. The phrase *engineering judgment* refers to technical judgments made by knowledgeable engineers experienced in the application of the Code. Engineering judgments must be consistent with Code philosophy, and such judgments must never be used to overrule mandatory requirements or specific prohibitions of the Code.

The Committee recognizes that tools and techniques used for design and analysis change as technology progresses and expects engineers to use good judgment in the application of these tools. The designer is responsible for complying with Code rules and demonstrating compliance with Code equations when such equations are mandatory. The Code neither requires nor prohibits the use of computers for the design or analysis of components constructed to the requirements of the Code. However, designers and engineers using computer programs for design or analysis are cautioned that they are responsible for all technical assumptions inherent in the programs they use and the application of these programs to their design.

*The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI’s requirements for an ANS. Therefore, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Code.

***Construction*, as used in this Foreword, is an all-inclusive term comprising materials, design, fabrication, examination, inspection, testing, certification, and overpressure protection.

Example SG2.21 Listing of Endnotes

ASME BPVC.III.1.NCD-2021

ENDNOTES

- 1 Because of the different thermal coefficients of expansion of dissimilar materials, caution shall be exercised in construction under the provisions of this paragraph in order to avoid difficulties in service under extreme temperature conditions, or with unusual restraint such as may occur at points of stress concentration and also because of metallurgical changes occurring at high temperatures.
- 2 Any postweld heat treatment time that is anticipated to be applied to the material or item after it is completed shall be specified in the Design Specification. The Certificate Holder shall include this time in the total time at temperature specified to be applied to the test specimens.
- 3 T_{NDT} — temperature at or above the nil-ductility transition temperature NDT (ASTM E208); T_{NDT} is 10°F(5°C) below the temperature at which at least two specimens show no-break performance.
- 4 *Lowest Service Temperature* (LST) is the minimum temperature of the fluid retained by the component or, alternatively, the calculated minimum metal temperature whenever the pressure within the component exceeds 20% of the preoperational system hydrostatic test pressure.
- 5 The *Lowest Service Metal Temperature* shall be the lowest temperature that the metal may experience in service while the plant is in operation and shall be established by appropriate calculations based on atmospheric ambient conditions, the insulation or enclosure provided, and the minimum temperature that will be maintained inside the vessel during the plant operation.
- 6 The requirements for impact testing of the heat-affected zone (NCD-4335.2) may result in reduced test temperatures or increased toughness requirements for the base material.
- 7 For pumps, valves, and fittings, use the nominal pipe wall thickness of the connecting pipe. For vessels, use the lesser of:
 - (a) the maximum radial thickness of the item, exclusive of integral butt welded projections;
 - (b) the vessel shell thickness to which the item is welded;
 - (c) the maximum shell thickness associated with the item for flat heads, tubesheets, or flanges.
- 8 The methods given in the Appendix of SFA-5.9, Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Rods and Bare Electrodes, shall be used to establish a welding and sampling method for the pad, groove, or other test weld to ensure that the weld deposit being sampled will be substantially free of base metal dilution.
- 9 The volumetric examinations required by this paragraph need only be conducted from one surface.
- 10 It is recognized that high localized and secondary stresses may exist in components designed and fabricated in accordance with the rules of this Subsection; however, insofar as practical, design rules for details have been written to hold such stresses at a safe level consistent with experience.
- 11 Thermal protection devices, such as thermal sleeves in nozzles, may be used to reduce temperature differences or thermal shock.
- 12 The head design curves have been developed considering membrane stress requirements, plastic collapse, cyclic load conditions, and the effects of maximum allowable tolerances in accordance with NCD-4222. See Section III Appendices, Nonmandatory Appendix A, Article A-4000 for the design equations for the curves of Figure NCD-3224.6-1.
- 13 The equations provide safe construction as far as stress is concerned. Greater thicknesses may be necessary if deflection would cause leakage at threaded or gasketed joints.
- 14 *Stress* means the maximum normal stress.
- 15 *Class 3 Vessels Only.* The rules governing openings as given in this Subsection are based on the stress intensification created by the existence of a hole in an otherwise symmetrical section. They are based on experience with vessels designed with design factors of 4 and 5 applied to the ultimate strength of the shell material. External loadings such as those due to the thermal expansion or unsupported weight of connecting piping have not been evaluated. These factors should be given attention in unusual designs or under conditions of cyclic loading.
- 16 The opening made by a pipe or a circular nozzle, the axis of which is not perpendicular to the vessel wall or head, may be considered an elliptical opening for design purposes.
- 17 An *obround opening* is one that is formed by two parallel sides and semicircular ends.
- 18 *Communicating chambers* are defined as appurtenances to the vessel that intersect the shell or heads of a vessel and form an integral part of the pressure-retaining enclosure, such as sumps.

Example SG2.22

Caution

ASME BPVC.XIII-2021

on size and design, to ensure that test results are repeatable and representative of field performance.

3.6.1 Pressure Testing

The requirements of 3.6.1 shall not apply to Section IV (HV Designator) pressure relief valves.

(a) The pressure-containing parts of the shell of each valve are subject to pressure testing. The valve shell is defined by parts such as the body, bonnet, and cap that isolate primary or secondary pressure from atmosphere.

(b) A valve shell part is exempt from pressure testing if both of the following conditions apply:

(1) The stress that would be applied under hydrostatic test conditions does not exceed 50% of the allowable stress.

(2) The part is not cast or welded.

(c) When the valve is designed for discharging directly to atmosphere, the valve components downstream of the valve disk are exempt from pressure testing.

(d) Valve components are exempt from pressure testing if they are fully contained within pressure-containing parts that have been either pressure tested or exempted from pressure testing by (b).

(e) A valve shell part requiring pressure testing shall be tested either

(1) hydrostatically at a minimum 1.5 times the design pressure of the part, or

(2) pneumatically at a minimum 1.25 times the design pressure of the part

CAUTION: Pneumatic testing can be hazardous; it is therefore recommended that special precautions be taken when conducting a pneumatic test.

(f) Pressure testing may be done in the part or assembled condition.

(g) Pressure testing shall be conducted after all machining and welding operations have been completed.

(h) Parts subjected to pressure testing shall not exhibit a sign of leakage.

3.6.2 Secondary Pressure Zone Test

(a) Except for the valves described in (b), all closed-bonnet pressure relief valves that have an inlet size exceeding DN 25 (NPS 1) and that are designed for discharge to a closed system shall have their secondary pressure zones tested with air or other gas at a pressure of at least 200 kPa (30 psi). The user may specify a higher test pressure commensurate with the back pressure anticipated in service.

(b) The secondary pressure zone of each Section VIII, Division 3 (UV Designator) closed-bonnet pressure relief valve shall be tested at 1.25 times the stated design pressure of the secondary pressure zone but not at less than 0.125 times the design pressure of the primary parts.

(c) Parts subjected to secondary pressure zone testing shall not exhibit a sign of leakage.

3.6.3 Set Pressure Tests

3.6.3.1 General

(a) Each pressure relief valve to which the Certification Mark and appropriate Designator is to be applied shall be tested by the Manufacturer or Assembler to demonstrate the valve's set pressure.

(b) Set pressure tests for pressure relief devices shall be conducted using the test fluid specified in Table 3.6.3.1-1.

(c) Test fixtures and test drums, where applicable, shall be of adequate size and capacity to ensure that pressure relief valve action is consistent with the marked set pressure within the applicable tolerances shown in Table 3.6.3.1-2.

(d) When pressure relief valve service conditions differ from test stand conditions due to superimposed back pressure or temperature, or both, the actual test pressure (cold differential test pressure) shall be adjusted and marked on the valve per 3.9(e)(4)(-a). When superimposed back pressure contributes to the cold differential test pressure, it shall also be marked on the valve per 3.9(e)(4)(-b).

(e) When pressure relief valves to be tested with steam, air, or other suitable gas are beyond the capability of the production test facility, either because of size or set pressure, the valves may be tested using an alternate test fluid. Steam service valves may be tested on air or other gas. Gas or vapor service valves may be tested on steam. The test pressure using an alternate fluid shall be the product of the Manufacturer's correction factor for the differential between steam and air or gas multiplied by the set pressure. If a cold differential test pressure is applicable due to superimposed back pressure or service temperature, or both, then the Manufacturer's correction factor shall be applied to the cold differential test pressure. The correction factor between steam and air or gas shall not be included in the cold differential test pressure marked on the valve per 3.9(e)(4)(-a).

3.6.3.2 Alternative Test Methods

(a) If testing of a direct spring-loaded pressure relief valve is beyond the capabilities of the production test equipment, an alternative test method [see (b)] may be used, provided all of the following conditions are met:

(1) Testing the valve at full pressure may cause damage to the valve, or testing of the valve is impractical due to safety considerations related to operating the boiler system.

(2) The valve lift has been mechanically verified as meeting or exceeding the required lift.

Example SG2.23 Deleted Paragraph

UHX-5.1 – UHX-9.1

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T_t = tube design temperature for the design condition or operating metal temperature for operating condition x , as applicable (see UHX-13.4(b) or UHX-14.4(c))	$\alpha_{t,m}$ = mean coefficient of thermal expansion of tube material at $T_{t,m}$
t_t = nominal tube wall thickness	γ = axial differential thermal expansion between tubes and shell
$T_{t,m}$ = mean tube metal temperature along tube length (see UHX-13.5.5 or UHX-13.6.4)	Δ_j = axial displacement over the length of the thin-walled bellows element (see UHX-16)
$T_{t,mx}$ = tube axial mean metal temperature for operating condition x , as applicable (see Table UHX-13.4-2, UHX-13.5.5 or UHX-13.6.4)	Δ_s = shell axial displacement over the length between the inner tubesheet faces, L (see UHX-17(c))
$U_{L1}, U_{L2}, \dots$ = center-to-center distance(s) between adjacent tube rows of untubed lane(s), but not to exceed $4p$ (see Figure UHX-11.5.1-2)	θ_{ecc} = eccentric cone half-apex angle, deg (see Figure UHX-13.10.3-1)
W = flange design bolt load from eq. 2-5(e)(5) considering UHX-4(b)	μ = basic ligament efficiency for shear
W_c = channel flange design bolt load for the gasket seating condition (see Mandatory Appendix 2)	μ^* = effective ligament efficiency for bending
W_{m1} = flange design bolt load from eq. 2-5(c)(1) (1) considering UHX-4(b)	ν = Poisson's ratio of tubesheet material
W_{m1c} = channel flange design bolt load (see definition for W_{m1} in Mandatory Appendix 2, 2-3)	ν_c = Poisson's ratio of channel material
W_{m1max} = MAX[(W_{m1c}), (W_{m1s})]	ν_{ecc} = Poisson's ratio of eccentric cone material
W_{m1s} = shell flange design bolt load (see definition for W_{m1} in Mandatory Appendix 2, 2-3)	ν_s = Poisson's ratio of shell material
W_{max} = MAX[(W_c), (W_s)]	$\nu_{s,L}$ = Poisson's ratio of large cylinder material
W_s = shell flange design bolt load for the gasket seating condition (see Mandatory Appendix 2)	ν_t = Poisson's ratio of tube material
W_t = tube-to-tubesheet joint load	ν^* = effective Poisson's ratio in perforated region of tubesheet
W^* = tubesheet effective bolt load selected from Table UHX-8.1 for the respective Configuration and Loading Case	ρ = tube expansion depth ratio = ℓ_{tx}/h , ($0 \leq \rho \leq 1$)
$X = 1, 2, 3, \dots, n$, integer denoting applicable operating condition under consideration (e.g., normal operating, start-up, shutdown, cleaning, upset)	
α' = mean coefficient of thermal expansion of tubesheet material at T' (see UHX-13.8 or UHX-14.6)	
α'_c = mean coefficient of thermal expansion of channel material at T'_c (see UHX-13.8 or UHX-14.6)	
α'_s = mean coefficient of thermal expansion of shell material at T'_s (see UHX-13.8 or UHX-14.6)	
$\alpha_{ecc,m}$ = mean coefficient of thermal expansion of eccentric cone material at $T_{s,m}$	
$\alpha_{s,m}$ = mean coefficient of thermal expansion of shell material at $T_{s,m}$	
$\alpha_{s,m,1}$ = mean coefficient of thermal expansion of shell material adjacent to tubesheets at $T_{s,m}$	
$\alpha_{s,m,L}$ = mean coefficient of thermal expansion of large cylinder material at $T_{s,m}$	

UHX-5.2 Welded Tube or Pipe

For a welded tube or pipe, use the allowable stress for the equivalent seamless product. When the allowable stress for the equivalent seamless product is not available, divide the allowable stress of the welded product by 0.85.

UHX-8 TUBESHEET EFFECTIVE BOLT LOAD, W^*

UHX-8.1 Scope

Table UHX-8.1 provides the tubesheet effective bolt load, W^* , transmitted to the perforated region of the tubesheet for each combination of Configuration and Loading Case. The bolt loads shall be calculated using the appropriate formula from Mandatory Appendix 2 considering the requirements in UHX-4(c).

UHX-8.2 Nomenclature

(21)

DELETED

UHX-9 TUBESHEET EXTENSION

UHX-9.1 Scope

(a) Tubesheet extensions, if present, may be extended as a flange (flanged) or not extended as a flange (unflanged).

(1) Configuration a tubesheets may have no extension or an unflanged extension.

(2) Configurations b, e, and B tubesheets have flanged extensions.

Example SG2.24 Deleted Tables

ASME BPVC.IV-2021

ARTICLE 3 DESIGN STRESSES AND MINIMUM THICKNESSES

(21) HF-300 MAXIMUM ALLOWABLE STRESS VALUES

Section II, Part D, Tables 6A and 6B give the maximum allowable stress values indicated for ferrous and nonferrous materials, respectively, conforming to the specifications listed therein.

HF-301 MINIMUM THICKNESSES²²

(21) HF-301.1 Ferrous Plates.

(a) Except as noted in (b) through (d), the minimum thickness of any ferrous plate, or pipe used in lieu of plate, under any pressure shall be $\frac{3}{32}$ in. (2.5 mm).

(b) Plates that will be exposed to primary furnace gases shall be not less than $\frac{3}{16}$ in. (5 mm).

(c) Alloy steel plates listed in Section II, Part D, Table 6A may be used when the following requirements are met:

(1) The material thickness of plates that will be exposed to primary furnace gases shall be not less than $\frac{3}{32}$ in. (2.5 mm).

(2) The material thickness of secondary flue gas heat exchanger surfaces shall be not less than 0.0394 in. (1 mm).

(d) The minimum thickness of any tubesheet with tubes installed by rolling shall be $\frac{1}{4}$ in. (6 mm).

HF-301.2 Nonferrous Plates.

(a) The minimum thickness of any nonferrous plate under pressure shall be $\frac{3}{32}$ in. (2.5 mm).

(b) The minimum thickness of any nonferrous tubesheet with tubes installed by rolling shall be $\frac{5}{16}$ in. (8 mm).

HF-302 BASIS FOR ESTABLISHING STRESS VALUES IN SECTION II, PART D, TABLE 6A OR TABLE 6B (21)

(a) In the determination of allowable stress values for pressure parts, the Committee is guided by successful experience in service, insofar as evidence of satisfactory performance is available. Such evidence is considered equivalent to test data where operating conditions are known with reasonable certainty. In the evaluation of new materials, it is necessary to be guided to a certain extent by the comparison of test information with similar data on successful applications of similar materials.

(b) At any temperature below the creep range, the allowable stresses are established at no higher than the lowest of the following:

(1) $\frac{1}{5}$ of the specified minimum tensile strength at room temperature

(2) $\frac{1}{5}$ of the tensile strength at temperature

(3) $\frac{2}{3}$ of the specified minimum yield strength at room temperature

(4) $\frac{2}{3}$ of the yield strength at temperature

(c) For bolting materials, the basis for setting stresses is the same as for all other materials with the exception that (1) and (2) above are

(1) $\frac{1}{4}$ of the specified minimum tensile strength at room temperature, and

(2) $\frac{1}{4}$ of the tensile strength at temperature

The following limitation also applies to bolting materials: at temperatures below the creep range, the stresses for materials whose strength has been enhanced by heat treatment or by strain hardening shall not exceed the lesser of 20% of the specified minimum tensile strength at room temperature or 25% of the specified minimum yield strength at room temperature unless these values are lower than the annealed values, in which case the annealed values shall be used.

Table HF-300.1

(21) **Maximum Allowable Stress Values for Ferrous
Materials, ksi
(Multiply by 1,000 to Obtain psi)**

DELETED

Table HF-300.1M

**Maximum Allowable Stress Values for Ferrous
Materials, MPa (21)**

DELETED

Example SG2.25 Code Case

ASME BPVC.CC.NC.S6-2021

CASE
N-508-5

Approval Date: July 6, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Case N-508-5
Rotation of Snubbers and Pressure Retaining Items for the Purpose of Testing or Preventive Maintenance
Section XI, Division 1

Inquiry: What alternative rules to those stated in IWA-4000 (IWA-7000 for Editions and Addenda prior to the 1991 Addenda) may be used when, for the purpose of testing or preventive maintenance, snubbers and pressure retaining items are rotated from stock and installed on components (including piping systems) within the Section XI boundary?

Reply: It is the opinion of the Committee that, as an alternative to the provisions of IWA-4000 (IWA-7000 for Editions and Addenda prior to the 1991 Addenda), snubbers and pressure retaining items¹ may be rotated from stock and installed on components (including piping systems) within the Section XI boundary provided the following requirements are met:

(a) The rotation shall be only for testing or preventive maintenance of the removed items;

(b) Items being removed and installed shall be of the same design and construction;

(c) Items being removed shall have no evidence of failure at the time of removal;

(d) Items being rotated shall be removed and installed only by mechanical means;

(e) Items being installed shall previously have been in service;

(f) The Owner shall track the items, by unique item identification, to ensure traceability of the installed location and inservice inspection and testing records;

(g) Use of an Inspector and an NIS-2 Form are not required except as provided in (h);

(h) Repair/Replacement activities on removed items, if required, shall be performed in accordance with IWA-4000 (IWA-4000 or IWA-7000 for Editions and Addenda prior to the 1991 Addenda).

¹ Examination and testing requirements for snubbers and testing requirements for pumps and valves are provided in the ASME Code for Operation and Maintenance of Nuclear Power Plants (OM Code).

The Committee's function is to establish rules of safety, relating only to pressure integrity, governing the construction of boilers, pressure vessels, transport tanks and nuclear components, and inservice inspection for pressure integrity of nuclear components and transport tanks, and to interpret these rules when questions arise regarding their intent. This Code does not address other safety issues relating to the construction of boilers, pressure vessels, transport tanks and nuclear components, and the inservice inspection of nuclear components and transport tanks. The user of the Code should refer to other pertinent codes, standards, laws, regulations or other relevant documents.

Example SG2.26
Errata to an ASME Standard

Errata to ASME B16.11-2016 Forged Fittings, Socket-Welding and Threaded

The errata corrections listed below apply to ASME B16.11-2016. Corrected entries in the Tables are shown in bold for the user's convenience.

<i>Page</i>	<i>Location</i>	<i>Change</i>
3	Table 2	(1) For Nominal Pipe Size 1, entry for "End-to-End Couplet, <i>M</i> " corrected to "42.9" (2) For Nominal Pipe Size 1, entry for "Weld Ring Diameter, <i>N</i> " corrected to "33.4"
6	Table 5	(1) For Nominal Pipe Size $\frac{3}{8}$, entry for "End-to-End Coupling, <i>W</i> " corrected to "38" (2) For Nominal Pipe Size $\frac{3}{8}$, entry for "End-to-End Caps, <i>P</i> " for 3000 corrected to "25" (3) For Nominal Pipe Size 3, entry for "Weld Ring Diameter, <i>N</i> " corrected to "88.9" (4) Reference to Table 2 corrected in General Note (b)
12	Table I-1	For Nominal Pipe Size $\frac{3}{4}$, entry for "Body Wall, <i>G</i> " for 3000 Min. corrected to "0.154"
13	Table I-2	For Nominal Pipe Size $\frac{1}{4}$, entry for "Socket Wall Thickness, <i>C</i> " for 3000 Avg. corrected to "0.149"
16	Table I-5	(1) For Nominal Pipe Size 3, entry for "Outside Diameter, <i>D</i> " for 3000 corrected to "4.25" (2) In General Note (a), millimeters corrected to read "inches"

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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June 2017



Example SG2.27
Special Errata to the ASME BPVC

SPECIAL ERRATA
to
ASME Boiler and Pressure Vessel Code
Section VIII, Division 2, 2004 Edition

<i>Page</i>	<i>Location</i>	<i>Change</i>
160	Table AF-402.1	For P-No. 6 Material, Normal Holding Temperature, °F (°C), Minimum corrected to read 1,400 (760)

TABLE AF-402.1
REQUIREMENTS FOR POSTWELD HEAT TREATMENT OF PRESSURE PARTS AND ATTACHMENTS (CONT'D)

Material	Normal Holding Temperature, °F (°C), Minimum	Minimum Holding Time at Normal Temperature for Nominal Thickness (See AF-402.1)		
		Up to 2 in. (50 mm)	Over 2 to 5 in. (50 to 125 mm)	Over 5 in. (125 mm)
P-No. 6 Group Nos. 1, 2, 3	1,400 (760)	1 hr/in. (1 hr/25 mm), 1 hr minimum	2 hr plus 15 min for each additional inch (25 mm) over 2 in. (50 mm)	2 hr plus 15 min for each additional inch (25 mm) over 2 in. (50 mm)

NOTES:

- (1) Postweld heat treatment is not required for vessels constructed of Type 410 material with carbon content not to exceed 0.08% and welded with electrodes that produce an austenitic chromium-nickel weld deposit or a nonair-hardening nickel-chromium iron weld deposit, provided the plate thickness at the welded joint does not exceed $\frac{3}{8}$ in. (10 mm), and for thicknesses over $\frac{3}{8}$ in. (10 mm) to $1\frac{1}{2}$ in. (38 mm) provided a preheat of 450°F (232°C) is maintained during welding and that the joints are completely radiographed.
- (2) If during the holding period of postweld heat treatment, the maximum time or temperature of any vessel component exceeds the provisions of AM-202, additional test coupons shall be made and tested.

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December 2006



B082E2

Example SG3.1 Vertical Positioning of Equation Numbers

ASME BPVC.III.1.NB-2021

$$S_p = K_1 C_1 \frac{P_o D_o}{2t} + K_2 C_2 \frac{D_o}{2I} M_i + \frac{1}{2(1-\nu)} K_3 E \alpha |\Delta T_1| + K_3 C_3 E_{ab} \times |\alpha_a T_a - \alpha_b T_b| + \frac{1}{1-\nu} E \alpha |\Delta T_2| \quad (11)$$

NOTE: This simplified analysis is intended to provide a value of S_p that conservatively estimates the sum of (P_m or P_L) + P_b + P_e + Q + F as required in Section III Appendices, Mandatory Appendix XIII, Figure XIII-2100-1.

The nomenclature used in eq. (11) is defined as follows:

- $E\alpha$ = modulus of elasticity, E , times the mean coefficient of thermal expansion, α , both at room temperature, psi/°F (MPa/°C)
- K_1, K_2, K_3 = local stress indices for the specific component under investigation (NB-3680)
- $|\Delta T_1|$ = absolute value of the range of the temperature difference between the temperature of the outside surface T_o and the temperature of the inside surface T_i of the piping product assuming moment generating equivalent linear temperature distribution, °F (°C)
- $|\Delta T_2|$ = absolute value of the range for that portion of the nonlinear thermal gradient through the wall thickness not included in ΔT_1 as shown below, °F (°C)

For a quantitative definition of $|\Delta T_1|$ and $|\Delta T_2|$, see (b) below. All other terms are as defined for eq. NB-3653.1(a)(10).

(b) Quantitative Definitions of $|\Delta T_1|$ and $|\Delta T_2|$. The following nomenclature is used:

- T_i = value of $T(y)$ at inside surface, °F (°C)
= $T(-t/2)$
- $T_j(y), T_k(y)$ = temperature, as a function of radial position, for load set j and load set k , respectively, °F (°C)
- T_o = value of $T(y)$ at outside surface, °F (°C)
= $T(t/2)$
- $T(y)$ = temperature distribution range from condition j to condition k , °F (°C)
= $T_k(y) - T_j(y)$
- t = thickness of the wall of the pipe or element, in. (mm)
- y = radial position in the wall, measured positive outward from the midthickness position ($-t/2 \leq y \leq t/2$), in. (mm)

Then the temperature distribution range $T(y)$ may be thought of as being composed of three parts:

(1) a constant value:

$$T = (1/t) \int_{-t/2}^{t/2} T(y) dy$$

that is the average value through the thickness. T may be used in determining free thermal expansions. Also, the values of T determined (for the same pair of load sets) or two locations a and b on either side of a gross discontinuity may be used for T_a and T_b in eqs. NB-3653.1(a)(10) and NB-3653.2(a)(11).

(2) a linear portion, with zero average value, having variation given by:

$$V = \left(12/t^2\right) \int_{-t/2}^{t/2} yT(y) dy$$

(3) a nonlinear portion with a zero average value and a zero first moment with respect to the mid-thickness. This decomposition of $T(y)$ into three parts is illustrated in Figure NB-3653.2(b)-1. The value of ΔT_1 to be used in eq. (a)(11) is the variation V of the linear portion:

$$\Delta T_1 = V$$

The value of ΔT_2 to be used in eq. (a)(11) is as follows:

$$\Delta T_2 = \max. \left(|T_o - T| - \frac{1}{2} |\Delta T_1|, |T_i - T| - \frac{1}{2} |\Delta T_1|, 0 \right)$$

NB-3653.3 Alternating Stress Intensity. The alternating stress intensity S_{alt} is equal to one-half the value of S_p ($S_{alt} = S_p/2$) calculated in eq. NB-3653.2(a)(11).

NB-3653.4 Use of Design Fatigue Curve. Enter the applicable design fatigue curve, Section III Appendices, Mandatory Appendix I, on the ordinate using $S_a = S_{alt}$, and find the corresponding number of cycles on the abscissa. If the service cycle being considered is the only one that produces significant fluctuating stresses, this is the allowable number of cycles.

NB-3653.5 Cumulative Damage. The cumulative damage shall be evaluated in accordance with Section III Appendices, Mandatory Appendix XIII, XIII-3520(e). If N_i is greater than the maximum number of cycles defined on the applicable design fatigue curve, the value of n_i/N_i may be taken as zero.

NB-3653.6 Simplified Elastic-Plastic Discontinuity Analysis. If eq. NB-3653.1(a)(10) cannot be satisfied for all pairs of load sets, the alternative analysis described below may still permit qualifying the component under NB-3650. Only those pairs of load sets that do not satisfy eq. NB-3653.1(a)(10) need be considered.

(a) Equation (12) shall be met:

$$S_e = C_2 \frac{D_o}{2I} M_i^* \leq 3S_m \quad (12)$$

Example SG3.2

Vertical Positioning of Equation Numbers: Variation

ASME NM.1-2020

excluding para. 2-3.2.1.2 but including the consideration of allowances permitted by paras. 2-2.2.4 and 2-2.4.

(2) *External Pressure Stress.* Piping subject to external pressure shall be considered safe when the wall thickness and means of stiffening meet the requirements of para. 2-3.2.1.2.

(3) *Longitudinal Pressure Stress.* For straight pipe, the sum of the longitudinal stresses, S_L , due to pressure, weight, and other sustained loads shall not exceed the basic material allowable stress, S , in the hot condition. Where the material has different properties in the axial and hoop directions, the allowable stress, S , shall be that applicable to the axial direction. The longitudinal pressure stress, S_{lp} , for pipe joined to transmit axial pressure thrust loads may be determined by eq. (2-2-3) or eq. (2-2-4):

$$S_{lp} = \frac{PD}{4t_n} \quad (2-2-3)$$

$$S_{lp} = \frac{Pd^2}{D^2 - d^2} \quad (2-2-4)$$

where

D = outside diameter, mm (in.)

d = inside diameter, mm (in.)

P = internal pressure, MPa (psig)

t_n = nominal thickness, mm (in.)

(4) *Combined Longitudinal Stress.* The sum of the longitudinal stresses produced by external pressure, live loads, dead loads, and other sustained loads shall meet the requirements of para. 2-3.3.1.1.

(b) *Displacement Limited Stress Range.* The calculated reference displacement stress range, per para. 2-3.3.1.3, shall not exceed the allowable stress range, S_A , as given in ASME NM.3.3 based on the fatigue properties for the given material at the given temperature. S_A shall be selected based on the total number of temperature cycles or the number of equivalent reference displacement stress range cycles, N , as determined below:

(1) *HDPE*

$$N = N_E + N_1 \left(\frac{\Delta T_1}{\Delta T_E} \right)^{5.0} + N_2 \left(\frac{\Delta T_2}{\Delta T_E} \right)^{5.0} + \dots + N_n \left(\frac{\Delta T_n}{\Delta T_E} \right)^{5.0} \quad (2-2-5)$$

where

$N_1, N_2, \dots, N_n$ = number of cycles at letter temperatures changes, $\Delta T_1, \Delta T_2, \dots, \Delta T_n$

N_E = number of cycles at maximum temperature change ΔT_E

$\Delta T_1, \Delta T_2, \dots, \Delta T_n$ = the lower temperature changes experienced by the pipe, °C (°F)

ΔT_E = maximum temperature change experienced by the pipe, °C (°F)

The maximum number of permitted equivalent full-range temperature cycles, N , shall be 100 000.

(2) *Materials Other Than HDPE.* The total number of thermal cycles shall be the sum of the cycles of each temperature change, $\Delta T_E, \Delta T_1, \Delta T_2, \dots, \Delta T_n$:

$$N = N_E + N_1 + N_2 + \dots + N_n \quad (2-2-6)$$

2-2.3.4 Limits of Calculated Stresses Due to Occasional Loads

(a) *During Operation.* The sum of the longitudinal stresses produced by internal pressure, live and dead loads, other sustained loads, and occasional loads shall meet the requirements of para. 2-3.3.1.2.

(b) *During Test.* During pressure tests performed in accordance with section 6-3, the circumferential (hoop) stress shall not exceed 150% of the allowable stress value given in ASME NM.3.3 at test temperature. In addition, the sum of longitudinal stresses due to test pressure, live and dead loads, and sustained loads at the time of test, excluding occasional loads, shall not exceed 120% of the allowable stress value given in ASME NM.3.3 at test temperature.

If any piping system or portion thereof is subjected to pressure or stress levels beyond these limits during the pressure testing, it shall be removed and replaced.

2-2.4 Design Allowances

2-2.4.1 Corrosion or Erosion. When corrosion or erosion is expected to occur, an increase in wall thickness of the piping shall be provided over that required by other design requirements. This allowance, in the judgment of the designer, shall be consistent with the expected life of the piping.

2-2.4.2 Threading. The allowances required for threading shall be determined in accordance with Mandatory Appendix II.

2-2.4.3 Mechanical Strength. Where enhancement of mechanical strength is necessary to prevent damage, collapse, excessive sag, or buckling of pipe due to superimposed loads, the wall thickness of the pipe should be increased. If this is impractical or would cause excessive local stresses, then the superimposed loads shall be reduced or eliminated by other design methods.

2-2.4.4 Material Quality Factors. Factors for the quality of material made to various manufacturing methods shall be reflected in the allowable design stress.

Example SG3.3 Multiline Equations Breaking on an Equal Sign

ASME NM.2-2020

III-2.2.1 Type I and Type II Elbows

(a) The following equation shall be used to calculate i for Type I and Type II long-radius elbows for which the diameter-to-structural-thickness ratio is not greater than 140, and for which the pipe size does not exceed 1 200 mm (48 in.) diameter:

$$i = \frac{\alpha_2 \gamma}{h^{0.667}} \quad (\text{III-2-7})$$

where

h = flexibility characteristic

$$= \frac{t_{es} R_1}{r^2}$$

r = inside radius of the elbow, mm (in.)

R_1 = radius of the bend, mm (in.)

= $1.5D$ where D is the inside diameter of the pipe

t_{es} = thickness of the structural wall of the elbow measured at the extrados, mm (in.)

α_2 = correction factor for reduction in SIF due to increased thickness at the intrados compared to the extrados; see (c) below

γ = correction factor for reduction in SIF due to internal pressure

$$= \left(1 + 2.53 \frac{Pr}{E_h t_e} \times R_1^{0.333} \frac{r}{t_e^{1.333}} \right)^{-1}$$

E_h = hoop modulus of the elbow, MPa (psi)

P = pressure, MPa (psi)

t_e = thickness of the total wall of the elbow measured at the extrados [including a corrosion-barrier thickness of at least 2.8 mm (0.11 in.)], mm (in.)

(b) Five SIFs are required to quantify the stresses in an elbow.

(1) longitudinal SIF due to in-plane moment, i_{ix} .

(2) longitudinal SIF due to out-of-plane moment, i_{ox} .

(3) hoop SIF due to in-plane moment, i_{ih} .

(4) hoop SIF due to out-of-plane moment, i_{oh} .

(5) shear stress SIF due to torsional moment, i_t . For Type I and Type II elbows, i_t may be taken to be 1.0.

(c) FRP elbows are often manufactured such that the thickness varies uniformly around the circumference of the elbow from a minimum at the extrados to a maximum at the intrados. An elbow with this additional thickness will have lower SIFs than an elbow that has a uniform thickness around its entire circumference. For Type I and Type II long-radius elbows, this reduction in SIF may be accounted for using the following values of α_2 :

(1) Type I Elbows

(-a) For i_{ih}

$$\begin{aligned} \alpha_2 &= 3.59 - 1.30 \times \left(\frac{t_{is}}{t_{es}} \right) \\ &= 1.64 \text{ if } \frac{t_{is}}{t_{es}} > 1.50 \end{aligned}$$

(-b) For i_{oh}

$$\begin{aligned} \alpha_2 &= 2.37 - 0.78 \times \left(\frac{t_{is}}{t_{es}} \right) \\ &= 1.20 \text{ if } \frac{t_{is}}{t_{es}} > 1.50 \end{aligned}$$

(-c) For i_{ix} and i_{ox}

$$\begin{aligned} \alpha_2 &= 2.15 - 0.74 \times \left(\frac{t_{is}}{t_{es}} \right) \\ &= 1.04 \text{ if } \frac{t_{is}}{t_{es}} > 1.50 \end{aligned}$$

where

t_{es} = thickness of the structural wall measured at the extrados, mm (in.)

t_{is} = thickness of the structural wall measured at the intrados, mm (in.)

(2) Type II Elbows

(-a) For i_{ih}

$$\begin{aligned} \alpha_2 &= 3.03 - 1.02 \times \left(\frac{t_{is}}{t_{es}} \right) \\ &= 1.50 \text{ if } \frac{t_{is}}{t_{es}} > 1.50 \end{aligned}$$

(-b) For i_{oh}

$$\begin{aligned} \alpha_2 &= 1.70 - 0.50 \times \left(\frac{t_{is}}{t_{es}} \right) \\ &= 0.95 \text{ if } \frac{t_{is}}{t_{es}} > 1.50 \end{aligned}$$

(-c) For i_{ix} and i_{ox}

$$\begin{aligned} \alpha_2 &= 1.62 - 0.52 \times \left(\frac{t_{is}}{t_{es}} \right) \\ &= 0.84 \text{ if } \frac{t_{is}}{t_{es}} > 1.50 \end{aligned}$$

III-2.2.2 Elbows Other Than Type I and Type II. For elbows other than Type I and Type II long-radius elbows, the SIFs shall be determined by testing or FEA, or by using historical values that have been documented to have been used successfully for a minimum of 5 yr.

III-2.2.3 Flanged Elbows. The SIFs for flanged elbows may be reduced by multiplying i by one of the following factors, c :

(a) For elbows with one flanged end

Example SG3.4 Multiline Equations Breaking on an Operator Other Than an Equal Sign

ASME BPVC.I-2021

$$\begin{aligned}
 A_3 &= 2t_n f_{t1} + \text{area present in lip} \\
 &= 2 \times 0.375 (15,000/17,500)(1.375) \\
 &\quad + 2 \times 0.5 \times 0.75 \\
 &= 1.634 \text{ in.}^2
 \end{aligned}$$

Area of reinforcement available in attachment welds
(see PG-36.4.3 and Figure PG-33.1)

$$\begin{aligned}
 A_{41} + A_{43} &= (WL_1^2 + WL_3^2)(S_n/S_v) \\
 &= (0.375^2 + 0.375^2)(15,000/17,500) \\
 &= 0.241 \text{ in.}^2
 \end{aligned}$$

Total area of reinforcement available

$$A_1 + A_2 + A_3 + A_{41} + A_{43} = 2.515 \text{ in.}^2 \geq A$$

as required for demonstration of compliance with PG-33.

Compliance with PG-37 and PW-15 is demonstrated by the following calculations:

Required minimum strength to be provided by the welds (see PG-37 and PW-15)

$$\begin{aligned}
 W &= (A - A_1) S_v \\
 &= (2.214 - 0.286) 17,500 \\
 &= 33,742 \text{ lb}
 \end{aligned}$$

Strength of the welds (see PG-37 and PW-15)

Internal fillet weld in shear

$$\begin{aligned}
 &= \frac{1}{2} \pi WL_3 \left(\text{O.D. lip} + WL_3 \right) \left(\text{factor in PW-15.2} \right) S_n \\
 &= \frac{1}{2} \times 3.142 \times 0.375 \times (5.25 + 0.375) \times 0.49 \\
 &\quad \times 15,000 \\
 &= 24,353 \text{ lb}
 \end{aligned}$$

External fillet weld in shear

$$\begin{aligned}
 &= \frac{1}{2} \pi WL_1 \left(dl + WL_1 \right) \left(\text{factor in PW-15.2} \right) S_n \\
 &= 0.5 \times 3.142 \times 0.375 \times (4.25 + 0.375) \\
 &\quad \times 0.49 \times 15,000 \\
 &= 20,027 \text{ lb}
 \end{aligned}$$

The combined strength of the welds equals 44,384 lb $\geq W$ as required for compliance with PG-37 and PW-15.

Verification of the minimum weld sizing as required by PW-16.1 and Figure PW-16.1, illustration (u-2), is demonstrated by the following:

Required per Figure PW-16.1, illustration (u-2)

$$\begin{aligned}
 t_1 + t_2 &\geq 1.25 t_{\min} \\
 t_1 &\geq 0.25 \\
 t_2 &\geq 0.25
 \end{aligned}$$

Actual per Figure A-66

$$\begin{aligned}
 t_1 &= WL_1 \sin 45^\circ \\
 &= 0.375 \times 0.7071 \\
 &= 0.265 \text{ in.} \\
 t_2 &= WL_3 \sin 45^\circ \\
 &= 0.375 \times 0.7071 \\
 &= 0.265 \text{ in.} \\
 t_{\min} &= 0.375 \text{ (based on } t_n)
 \end{aligned}$$

Verification

$$\begin{aligned}
 (t_1 + t_2 = 0.530) &\geq (1.25 t_{\min} = 0.469) \\
 (t_1 = 0.265) &\geq 0.25 \\
 (t_2 = 0.265) &\geq 0.25
 \end{aligned}$$

As verified by the above demonstrations, the design is proved to be in compliance with the requirements of Section I.

A-67

A vessel shell has a studding outlet connection mounted as shown in Figure A-67. The maximum allowable stress of both the vessel and studding outlet material is 12,500 psi. The maximum allowable working pressure of the design is 325 psig. See Figure A-67 for vessel and studding outlet dimensions.

The studding outlet conforms to the requirements of PG-39.4, both in arrangement and in tapped stud hole requirements. The welded attachment does not qualify for the exception provided in PG-32 and must therefore comply with PG-33 as follows:

Minimum required thickness for reinforcement consideration

$$\begin{aligned}
 \text{Shell } t_r &= \frac{PR_v}{S_v - (1 - y)P} \\
 &= \frac{325 \times 30}{12,500 - (1 - 0.4) \times 325} \\
 &= 0.792 \text{ in.}
 \end{aligned}$$

Nozzle $t_{rn} = 0.0$ [see Figure PG-33.2, illustration (a)]

Area of reinforcement required (see PG-33.2)

$$\begin{aligned}
 A &= t_r Fd \\
 &= 0.79236 \times 1.0 \times 7.5 \\
 &= 5.943 \text{ in.}^2
 \end{aligned}$$

Area of reinforcement available in the vessel wall (see PG-36.4.1)

$$\begin{aligned}
 A_1 &= (t - Ft_r) d \\
 &= (1.0 - 1.0 \times 0.79236) \times 7.5 \\
 &= 1.557 \text{ in.}^2
 \end{aligned}$$

Area of reinforcement available in attachment welds (see PG-36.4.3)

Example SG3.5 Acronyms and Initialisms in Equations

ASME AG-1-2019

rate. When using a totalizing gas volume meter, measure the total volume of air for a 10 min continuous period and divide the measured volume by time (10 min) to calculate the measured leak rate. Record final pressure, temperature and barometric pressure.

(g) Convert the final calculated leak rate to standard cfm (m^3/s) in accordance with the method illustrated in AGCIH Industrial Ventilation (see [Article TA-2000](#)).

TA-III-4200 PRESSURE DECAY TEST

(a) Connect the pressurization source (with a leak-tight shutoff valve) to the duct or housing.

(b) Install the temperature- and pressure-indicating devices where they will indicate representative temperature and pressure inside the duct or housing being tested.

(c) Seal test boundaries and close access doors in the normal manner. Do not use temporary sealants, duct tape, or similar temporary materials except for sealing the temporary blank-off panels.

(d) Start the pressurization source and operate until the pressure is 1.25 times the maximum operating pressure but not to exceed the structural capability pressure (see [Note](#) herein). Maintain this pressure constant with a flow control device until temperature remains constant within $\pm 0.5^\circ\text{F}$ (0.25°C) for a minimum of 10 min. Close shutoff valve.

NOTE: If the structural capability pressure for the duct or housing is less than $1\frac{1}{4}$ times the maximum operating pressure, the initial and final test pressures shall be calculated as follows to achieve an average test pressure equal to the maximum operating pressure:

$$P_i = 0.8\text{OP}_{\max} + (1.25\text{OP}_{\max} - \text{SCP})$$

$$P_f = (\text{OP}_{\max} - P_i) + \text{OP}_{\max}$$

where

$\text{OP}_{\max}$ = maximum operating pressure

P_f = final test pressure

P_i = initial pressure

SCP = structural capability pressure

(e) Record the initial time, pressure, temperature, and barometric pressure.

(f) Close shutoff valve.

(g) Record pressure readings once a minute until pressure decays to 75% of the maximum operating pressure, or for a minimum of 15 min [see [Note](#) in (d)].

(h) Record final time, pressure, temperature, and barometric pressure.

(i) Calculate leak rate from the following equation:

(U.S. Customary Units)

$$Q_{\text{avg}} = \left(\frac{P_i}{T_i} - \frac{P_f}{T_f} \right) \times \frac{V}{R \times \Delta t \times 0.075}$$

(SI Units)

$$Q_{\text{avg}} = \left(\frac{P_i}{T_i} - \frac{P_f}{T_f} \right) \times \left(\frac{V}{R \times \Delta t \times 60 \times 1.201} \right)$$

where

P_f = final pressure within test boundary, lb/ft^2 ABS
[Pa(absolute)]

P_i = initial pressure within test boundary, lb/ft^2 ABS
[Pa(absolute)]

Q_{avg} = average leak rate, scfm (L/s) [air density = 0.075
 lb/ft^3 ($1.201 \text{ kg}/\text{m}^3$)]

R = gas constant for air, 53.35 $\text{ft}\cdot\text{lb}/\text{lb}\cdot^\circ\text{R}$ ($0.286 \text{ kJ}/\text{kg K}$)

T_f = absolute temperature at end of test, $^\circ\text{R}$ (K)

t_f = time at end of test, min

T_i = absolute temperature at start of test, $^\circ\text{R}$ (K)

t_i = time at start of test, min

V = volume within test boundary, ft^3 (m^3)

$\Delta t = t_f - t_i$ time difference, min

TA-III-4300 ACCEPTANCE CRITERIA

If the calculated leak rate exceeds the Owner's acceptance criteria, locate leaks in accordance with one of the techniques outlined in [TA-III-4400](#) or [TA-III-4500](#).

TA-III-4400 BUBBLE LEAK LOCATION METHOD

(a) Pressurize the test boundary to the maximum operating pressure for the system.

(b) With the test boundary under continuous pressure, apply bubble solution to areas to be tested. Identify places where bubbles are found and perform corrective actions.

(c) Following corrective actions, retest in accordance with [TA-III-4100](#) or [TA-III-4200](#).

TA-III-4500 AUDIBLE LEAK LOCATION METHOD

(a) Pressurize the test boundary to the maximum operating pressure for the system.

(b) With the test boundary continuously pressurized, locate audible leaks (electronic sound detection equipment optional) and perform corrective actions.

(c) Following corrective action, retest in accordance with [TA-III-4100](#) or [TA-III-4200](#).

Example SG3.6 Nomenclature for a Series of Equations

ASME NM.1-2020

2-3 PRESSURE DESIGN OF PIPING COMPONENTS

2-3.1 Criteria for Pressure Design of Piping Components

The design of piping components shall consider the effects of pressure and temperature, in accordance with [paras. 2-3.2.1 through 2-3.2.7](#), including the consideration of variations and allowances permitted by [paras. 2-2.2.4 and 2-2.4](#). In addition, the mechanical strength of the piping system shall be determined adequate in accordance with [para. 2-3.3](#) under other applicable loadings, including, but not limited to, those loadings and conditions defined in [sections 2-1 and 2-2](#).

2-3.2 Pressure Design of Components

2-3.2.1 Straight Pipe

(20) 2-3.2.1.1 Straight Pipe Under Internal Pressure

(a) The minimum required wall thickness, $t_{\min}$, of straight pipe sections for pressure design shall be determined by the following:

(1) For O.D.-controlled pipe

$$t_{\min} = \frac{P_D D}{2S + P_D} + A \quad (2-3-1)$$

(2) For I.D.-controlled pipe

$$t_{\min} = \frac{P_D d + 2SA + P_D A}{2S - P_D} \quad (2-3-2)$$

where

A = an allowance to be determined by the designer for threading, grooving, erosion, or other wall loss mechanisms, mm (in.)

D = specified or actual outside diameter, mm (in.)

d = specified or actual inside diameter, mm (in.)

P_D = design pressure, MPa (psig)

S = maximum allowable stress from ASME NM.3.3, Table 1-1-1, MPa (psi)

When the pipe is subjected to scratches, dents, or other damage during construction, the remaining pipe wall thickness shall be greater than or equal to $t_{\min}$ plus any erosion or other required allowance.

(b) The maximum allowable working pressure, P_a , shall be determined as follows:

(1) For O.D.-controlled pipe

$$P_a = \frac{2S(t - A)}{D - (t - A)} \quad (2-3-3)$$

(2) For I.D.-controlled pipe

$$P_a = \frac{2S(t - A)}{d - (t - A) + 2t} = \frac{2S(t - A)}{d + A + t} \quad (2-3-4)$$

where

t = minimum wall thickness from the standard to which the pipe was made, accounting for manufacturing tolerances, or the minimum measured wall thickness, mm (in.)

2-3.2.1.2 Straight Pipe Under External Pressure. See [Nonmandatory Appendix B](#) for recommended requirements for external pressure design of buried piping systems.

2-3.2.1.3 Allowable Pressure Due to Pressure Spikes. For straight pipe made of HDPE, the sum of the maximum anticipated operating pressure plus the maximum anticipated occasional pressure spikes shall be not greater than $1.5P_D$. The maximum permitted duration of the pressure spike is 15 min, and the total duration of the pressure spikes shall be less than 20 h/yr.

2-3.2.2 Joints or Fittings. This paragraph provides the design requirements and limitations for joints or fittings in thermoplastic piping systems.

(a) *General Requirements for All Thermoplastics*

(1) See [Chapter 5](#) for allowable joining methods for each type of listed thermoplastic.

(2) The piping components permitted in [section 2-3](#) shall be designed to withstand a pressure greater than or equal to the design pressure of the attached pipe.

(3) See [Mandatory Appendix II](#) for requirements on threaded thermoplastic connections.

(4) See [Mandatory Appendix III](#) for acceptance criteria for thermoplastic joints.

(5) See [Mandatory Appendix V](#) and [Nonmandatory Appendix A](#) for requirements and information on thermoplastic flanges and flange connections.

(b) *Requirements Specific to HDPE.* Pipe fittings, including electrofusion fittings, shall be designed to withstand a pressure greater than or equal to the design pressure, P_D , of the attached HDPE pipe.

(1) The pressure rating (PR) of the fitting shall be determined by testing or by the following calculation:

$$PR = GSR \left(\frac{2S}{DR - 1} \right) \geq P_D \quad (2-3-5a)$$

where GSR is the geometric shape rating factor per [Table 2-3.2.2-1](#) and DR is the dimensional ratio (D/t).

(2) For components of different DRs, the item with the smaller DR shall be counterbored and tapered to equal the wall thickness of the item with the larger DR, or its outside diameter shall be machined and tapered to equal the wall thickness of the item with the larger DR and shall comply with [Figure 2-3.2.2-1](#), illustration (a) or illustration (b), as applicable. This requirement shall be identified on the design and fabrication drawings.

Example SG3.7

Nomenclature for an Entire Chapter or Standard

ASME BPVC.VIII.1-2021

13-4 - 13-5

(j) Openings may be provided in vessels of noncircular cross section as follows:

(1) Openings in noncircular vessels do not require reinforcement other than that inherent in the construction, provided they meet the conditions given in UG-36(c)(3).

(2) As a minimum, the reinforcement of other openings in noncircular vessels shall comply with UG-39, except the required thickness to be used in the reinforcement calculations shall be the thickness required to satisfy the stress criteria in (b). Compensation for openings in noncircular vessels must account for the bending strength as well as the membrane strength of the side with the opening. In addition, openings may significantly affect the stresses in adjacent sides. Because many acceptable configurations are possible, rules for specific designs are not provided [see U-2(g)].

(k) For vessels without reinforcements and for vessels with stay plates and stay rods (13-7, 13-9, 13-10, 13-12, and 13-13), the moments of inertia are calculated on a per-unit-width basis. That is, $I = bt^3/12$, where $b = 1.0$. For vessels with reinforcements that do not extend around the corners of the vessel (13-8 and 13-11), the moments of inertia are calculated using the traditional definition, $I = pt^3/12$. For width of cross section for vessels with reinforcements, see 13-8(d). For unreinforced vessels of rectangular cross section (13-7), the given moments are defined on a per-unit-width basis. That is, M_A and M_r have dimensions (length $\times$ force/length) = force.

13-5 NOMENCLATURE

Symbols used in this Appendix are as follows:

- $A = R(2\gamma + \pi\alpha_2)$
 A_1 = cross-sectional area of reinforcing member only attached to plate of thickness t_1
 A_2 = cross-sectional area of reinforcing member attached to plate of thickness t_2
 $A_3 = r(2\gamma_1 + \pi)$
 $B = R^2(\gamma^2 + \pi\gamma\alpha_2 + 2\alpha_2)$
 $b_1 = p - d_1$ (Figure 13-6)
 $b_2 = p - d_2$ (Figure 13-6)
 $b_n = p - d_n$ (Figure 13-6)
 $b_o = p - d_o$ (Figure 13-6)
 C = plate coefficient, UG-47
 c = distance from neutral axis of cross section to extreme fibers (see c_i and c_o). The appropriate c_i or c_o value shall be substituted for the c term in the stress equations.
 $C_1 = R^2(2\gamma^2 + 3\gamma\pi\alpha_2 + 12\alpha_2)$
 $C_2 = r^2(2\gamma_1^2 + 3\pi\gamma_1 + 12)$
 c_i = distance from neutral axis of cross section of plate, composite section, or section with multidiameter holes (see 2-12) to the inside surface of the vessel. Sign is always positive (+).

c_o = distance from neutral axis of cross section of plate, composite section, or section with multidiameter holes (see 2-12) to the extreme outside surface of the section. Sign is always negative (-).
 $\pm c_x$ = distance from neutral axis of cross section to any intermediate point. Sign is positive (+) when inward and sign is negative (-) when outward.

$D_1 = R^3(\gamma^3 + 2\pi\gamma^2\alpha_2 + 12\gamma\alpha_2 + 2\pi\alpha_2)$
 d_1 = diameter of hole of length T_1 (pitch diameter for threaded hole) (Figure 13-6)

d_2 = diameter of hole of length T_2 (pitch diameter for threaded hole) (Figure 13-6)

D_E = equivalent uniform diameter of multidiameter hole

d_j = distance from midlength of plate to weld joint or centerline of row of holes in the straight segment of the plate

d_n = diameter of hole of length T_n (pitch diameter for threaded hole) (Figure 13-6)

d_o = diameter of hole of length T_o (pitch diameter for threaded hole) (Figure 13-6)

E = joint efficiency factor as required by UW-12 for all Category A butt joints (see UW-3) and to any Category C or D butt⁷⁴ joints. The joint efficiency factor is used as described in 13-4(b) and 13-4(g) to calculate the allowable design membrane and membrane plus bending stresses.

$E_1 = R^3(4\gamma^3 + 6\pi\gamma^2\alpha_2 + 24\gamma\alpha_2 + 3\pi\alpha_2)$

E_2 = modulus of elasticity at design temperature

E_3 = modulus of elasticity at ambient temperature

e_b = bending ligament efficiency [see 13-4(g), 2-12, and 13-18(b)]

e_m = membrane ligament efficiency [see 13-4(g), 2-12, and 13-18(b)]

$F = (3AD_1 - 2BC_1)/(AE_1 - 6B^2)$

H = inside length of short side of rectangular vessel

$= 2(L_1 + L_{11})$ for equations in 13-8(d) for Figure 13-2(a), sketches (5) and (6)

h = inside length of long side of unstayed rectangular vessel; or dimension perpendicular to the H dimension in stayed vessels as shown in Figure 13-2(a), sketches (7), (8), (9), and (10), in which case h may be greater than, equal to, or less than H ,

$= 2(L_2 + L_{21})$ for equations in 13-8(d) for Figure 13-2(a), sketches (5) and (6)

$= 2L_2$ for equations in 13-8(d) for Figure 13-2(b), sketch (2)

H_0 = outside length of short side of rectangular vessel

H_1 = centroidal length of reinforcing member on short side of rectangular vessel

Example SG3.8 Variables With Multiple Definitions

ASME BPVC.VIII.1-2021

13-4 – 13-5

(j) Openings may be provided in vessels of noncircular cross section as follows:

(1) Openings in noncircular vessels do not require reinforcement other than that inherent in the construction, provided they meet the conditions given in UG-36(c)(3).

(2) As a minimum, the reinforcement of other openings in noncircular vessels shall comply with UG-39, except the required thickness to be used in the reinforcement calculations shall be the thickness required to satisfy the stress criteria in (b). Compensation for openings in noncircular vessels must account for the bending strength as well as the membrane strength of the side with the opening. In addition, openings may significantly affect the stresses in adjacent sides. Because many acceptable configurations are possible, rules for specific designs are not provided [see U-2(g)].

(k) For vessels without reinforcements and for vessels with stay plates and stay rods (13-7, 13-9, 13-10, 13-12, and 13-13), the moments of inertia are calculated on a per-unit-width basis. That is, $I = bt^3/12$, where $b = 1.0$. For vessels with reinforcements that do not extend around the corners of the vessel (13-8 and 13-11), the moments of inertia are calculated using the traditional definition, $I = pt^3/12$. For width of cross section for vessels with reinforcements, see 13-8(d). For unreinforced vessels of rectangular cross section (13-7), the given moments are defined on a per-unit-width basis. That is, M_A and M_r have dimensions (length $\times$ force/length) = force.

(21) 13-5 NOMENCLATURE

Symbols used in this Appendix are as follows:

- $A = R(2\gamma + \pi\alpha_2)$
 A_1 = cross-sectional area of reinforcing member only attached to plate of thickness t_1
 A_2 = cross-sectional area of reinforcing member attached to plate of thickness t_2
 $A_3 = r(2\gamma_1 + \pi)$
 $B = R^2(\gamma^2 + \pi\gamma\alpha_2 + 2\alpha_2)$
 $b_1 = p - d_1$ (Figure 13-6)
 $b_2 = p - d_2$ (Figure 13-6)
 $b_n = p - d_n$ (Figure 13-6)
 $b_o = p - d_o$ (Figure 13-6)
 C = plate coefficient, UG-47
 c = distance from neutral axis of cross section to extreme fibers (see c_i and c_o). The appropriate c_i or c_o value shall be substituted for the c term in the stress equations.
 $C_1 = R^2(2\gamma^2 + 3\gamma\pi\alpha_2 + 12\alpha_2)$
 $C_2 = r^2(2\gamma_1^2 + 3\pi\gamma_1 + 12)$
 c_i = distance from neutral axis of cross section of plate, composite section, or section with multidiameter holes (see 2-12) to the inside surface of the vessel. Sign is always positive (+).

c_o = distance from neutral axis of cross section of plate, composite section, or section with multidiameter holes (see 2-12) to the extreme outside surface of the section. Sign is always negative (-).

$\pm c_x$ = distance from neutral axis of cross section to any intermediate point. Sign is positive (+) when inward and sign is negative (-) when outward.

$$D_1 = R^3(\gamma^3 + 2\pi\gamma^2\alpha_2 + 12\gamma\alpha_2 + 2\pi\alpha_2)$$

d_1 = diameter of hole of length T_1 (pitch diameter for threaded hole) (Figure 13-6)

d_2 = diameter of hole of length T_2 (pitch diameter for threaded hole) (Figure 13-6)

D_E = equivalent uniform diameter of multidiameter hole

d_j = distance from midlength of plate to weld joint or centerline of row of holes in the straight segment of the plate

d_n = diameter of hole of length T_n (pitch diameter for threaded hole) (Figure 13-6)

d_o = diameter of hole of length T_o (pitch diameter for threaded hole) (Figure 13-6)

E = joint efficiency factor as required by UW-12 for all Category A butt joints (see UW-3) and to any Category C or D butt⁷⁴ joints. The joint efficiency factor is used as described in 13-4(b) and 13-4(g) to calculate the allowable design membrane and membrane plus bending stresses.

$$E_1 = R^3(4\gamma^3 + 6\pi\gamma^2\alpha_2 + 24\gamma\alpha_2 + 3\pi\alpha_2)$$

E_2 = modulus of elasticity at design temperature

E_3 = modulus of elasticity at ambient temperature

e_b = bending ligament efficiency [see 13-4(g), 2-12, and 13-18(b)]

e_m = membrane ligament efficiency [see 13-4(g), 2-12, and 13-18(b)]

$$F = (3AD_1 - 2BC_1)/(AE_1 - 6B^2)$$

H = inside length of short side of rectangular vessel

$= 2(L_1 + L_{11})$ for equations in 13-8(d) for Figure 13-2(a), sketches (5) and (6)

h = inside length of long side of unstayed rectangular vessel; or dimension perpendicular to the H dimension in stayed vessels as shown in Figure 13-2(a), sketches (7), (8), (9), and (10), in which case h may be greater than, equal to, or less than H ,

$= 2(L_2 + L_{21})$ for equations in 13-8(d) for Figure 13-2(a), sketches (5) and (6)

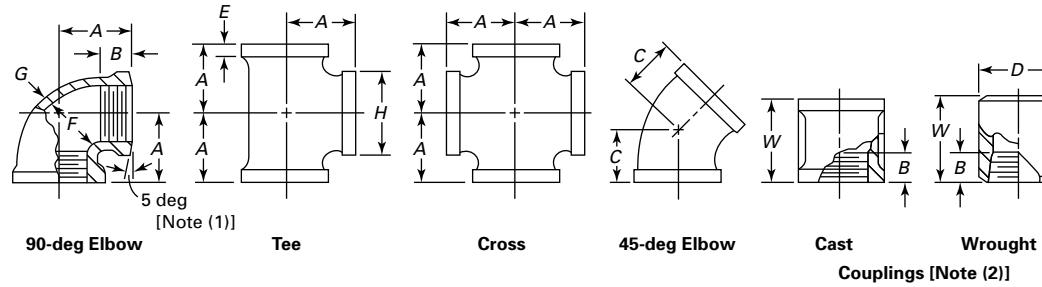
$= 2L_2$ for equations in 13-8(d) for Figure 13-2(b), sketch (2)

H_o = outside length of short side of rectangular vessel

H_1 = centroidal length of reinforcing member on short side of rectangular vessel

Example SG4.1
Table Styled per SG4-2

Table 7.1.3-1
Dimensions of 90-deg Elbows, Tees, Crosses, 45-deg Elbows, and Couplings (Straight Sizes) — Class 125



NPS	Center-to-End Elbows, Tees, and Crosses, <i>A</i> , mm (in.)	Minimum Length of Thread, <i>B</i> , mm (in.) [Note (2)]	Center-to-End, 45-deg Elbows, <i>C</i> , mm (in.)	Wrought Coupling Diameter, <i>D</i> , mm (in.) [Note (3)]	Minimum Band Length, <i>E</i> , mm (in.)	Inside Diameter of Cast Fitting, <i>F</i> , mm (in.)		Metal Thickness, <i>G</i> , mm (in.) [Note (4)]	Minimum Band Diameter, <i>H</i> , mm (in.)	End-to-End Straight Coupling, <i>W</i> , mm (in.)	
						Min.	Max.			Cast	Wrought
1/8	14 (0.54)	6 (0.25)	11 (0.42)	14 (0.56)	4 (0.14)	10 (0.41)	11 (0.44)	2.0 (0.08)	17 (0.67)	20 (0.80)	21 (0.83)
1/4	18 (0.71)	8 (0.32)	14 (0.56)	17 (0.69)	4 (0.16)	14 (0.54)	15 (0.58)	2.0 (0.08)	21 (0.81)	25 (0.97)	26 (1.03)
3/8	21 (0.82)	9 (0.36)	16 (0.63)	21 (0.84)	4 (0.17)	17 (0.68)	18 (0.72)	2.2 (0.09)	25 (1.00)	27 (1.05)	28 (1.11)
1/2	26 (1.01)	11 (0.43)	20 (0.78)	27 (1.06)	5 (0.19)	21 (0.84)	23 (0.90)	2.2 (0.09)	30 (1.17)	33 (1.29)	35 (1.36)
3/4	30 (1.18)	13 (0.50)	23 (0.89)	33 (1.31)	6 (0.23)	27 (1.05)	28 (1.11)	2.5 (0.10)	36 (1.42)	36 (1.43)	38 (1.50)
1	36 (1.43)	15 (0.58)	27 (1.06)	...	7 (0.27)	34 (1.32)	35 (1.39)	2.7 (0.11)	44 (1.72)	43 (1.68)	...
1 1/4	43 (1.69)	17 (0.67)	31 (1.22)	...	8 (0.31)	42 (1.66)	44 (1.73)	3.0 (0.12)	53 (2.10)	47 (1.86)	...
1 1/2	47 (1.84)	18 (0.70)	33 (1.30)	...	9 (0.34)	48 (1.90)	50 (1.97)	3.3 (0.13)	60 (2.38)	49 (1.92)	...
2	54 (2.12)	19 (0.75)	37 (1.45)	...	10 (0.41)	60 (2.38)	62 (2.45)	3.8 (0.15)	74 (2.92)	56 (2.20)	...
2 1/2 [Note (5)]	69 (2.70)	23 (0.92)	50 (1.95)	...	12 (0.48)	73 (2.88)	76 (2.98)	4.3 (0.17)	89 (3.49)	73 (2.88)	...
3	78 (3.08)	25 (0.98)	55 (2.17)	...	14 (0.55)	89 (3.50)	91 (3.60)	4.8 (0.19)	107 (4.20)	81 (3.18)	...
4	96 (3.79)	27 (1.08)	66 (2.61)	...	17 (0.66)	114 (4.50)	117 (4.60)	5.5 (0.22)	135 (5.31)	94 (3.69)	...

NOTES:

- (1) A 5-deg bevel on the face is optional.
- (2) Dimension *B* for wrought couplings includes minimum length of perfect thread. The length of useful thread (*B* plus threads with fully formed roots and flat crests) shall not be less than L_2 (effective length of external thread) required by ASME B1.20.1. See [section 7](#).
- (3) Couplings size NPS 3/4 and smaller may be cast or made from bar at the option of the manufacturer. Diameter, *D*, is in commercial bar sizes.
- (4) For metal thickness tolerance, see [para. 11.2](#).
- (5) The dimensions for NPS 2 1/2 and larger are in accordance with ASME B16.3 for Class 150 malleable iron threaded fittings.

Example SG4.2

Vertical Rules for Spanner Column Headings

ASME PCC-2-2022

Table 208-3.3-1
Comparison of Specification and Actual Weld Metal Properties

Filler Metal	Specification Requirements, ksi		Typical As-Welded, ksi		Typical Stress Relieved, ksi	
	Ultimate	Yield	Ultimate	Yield	Ultimate	Yield
E6013	62	50	74	64	...	...
E6018	67	55	68	57	...	...
E7018	72	60	87	79	83 [Note (1)]	74 [Note (1)]
E7018-A1	70 [Note (1)]	57 [Note (1)]	90	71	84 [Note (1)]	70 [Note (1)]
E8018-B2	80 [Note (2)]	68 [Note (2)]	118	103	95 [Note (1)]	79 [Note (1)]
E9018-B3	90 [Note (2)]	77 [Note (2)]	141	127	101 [Note (1)]	87 [Note (1)]
E9015-B9	90 [Note (3)]	77 [Note (3)]	210	...	120 [Note (4)]	100 [Note (4)]
ER70S-2	70	58	74	60	...	...
ER70S-6	72	60	94 [Note (5)]	75 [Note (5)]	85 [Notes (1), (5)]	71 [Notes(1), (5)]
ER80S-D2	80	68	110	79	100 [Note (2)]	86 [Note (2)]
ER70S-A1	80 [Note (6)]	68 [Note (6)]	92	79	90 [Note (2)]	72 [Note (2)]
ER90S-B3	90 [Note (2)]	78 [Note (2)]	...	...	104 [Note (2)]	93 [Note (2)]

NOTES:

- (1) Stress relieved @ 621°C (1,150°F) for 1 h.
 (2) Stress relieved @ 690°C (1,275°F) for 1 h.
 (3) Stress relieved @ 746°C (1,375°F) for 1 h.
 (4) Stress relieved @ 760°C (1,400°F) for 1 h.
 (5) GTAW process.
 (6) SGMo DIN 8575, Wks. No. 1.5424.

208-3.5 Cracking Parameter (Pcm)

Where carbon content is equal to or less than 0.17 wt.% or where high-strength steels are involved, the Ito and Bessyo Cracking Parameter (Pcm) can be used. This approach provides a more accurate prediction for when preheat will be needed, when preheat is mandatory, and at what recommended temperature.

Where [Pcm in wt. %]:

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn + Cu + Cr}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B2$$

$$P_{cm} \leq 0.15\%; \text{ preheat is normally optional}$$

$$0.15\% < P_{cm} < 0.26\% \text{ to } 0.28\%; \text{ preheat } 200^{\circ}\text{F to } 400^{\circ}\text{F}$$

$$P_{cm} > 0.26\% \text{ to } 0.28\%; \text{ preheat } 400^{\circ}\text{F to } 700^{\circ}\text{F}$$

208-3.6 Controlled Deposition Welding

(a) Use of controlled deposition (temper bead) procedures can be useful to generate fine grain heat-affected zones and improve notch toughness. This method should be considered when either elevated preheat or code-required postweld heat treatment cannot be used.

Rules for qualification of procedures are included in API 510, 7.2.3; ASME BPVC, Section IX, QW-290; and ANSI NB-23.

(b) Where similar composition weld metal is used, this method will NOT lower residual stresses. An evaluation to consider the effect of welding residual stresses should be conducted where this method is to be used.

208-4 FABRICATION

In order to use alternative preheating strategies, fabrication techniques should be carefully controlled to avoid the problems that preheat would be employed to mitigate. Welding processes and consumables that are less likely to introduce hydrogen can be chosen over other options. Certain techniques can minimize or reduce residual stresses. Careful monitoring should be done to ensure that alternatives are employed properly. The following describe or are important for successful implementation of these techniques.

208-4.1 Cleanliness

Contaminants (dirt, grease, moisture, etc.) should always be removed prior to application of any welding.

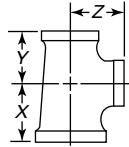
208-4.2 Welding Technique

The technique used during welding has a significant effect on shrinkage, resulting residual stresses, controlling heat input, and avoiding cracking issues.

Example SG4.3 Snaked Table

ASME B16.4-2021

Table 7.1-3
Dimensions of Class 125 Tees (Reducing Sizes)

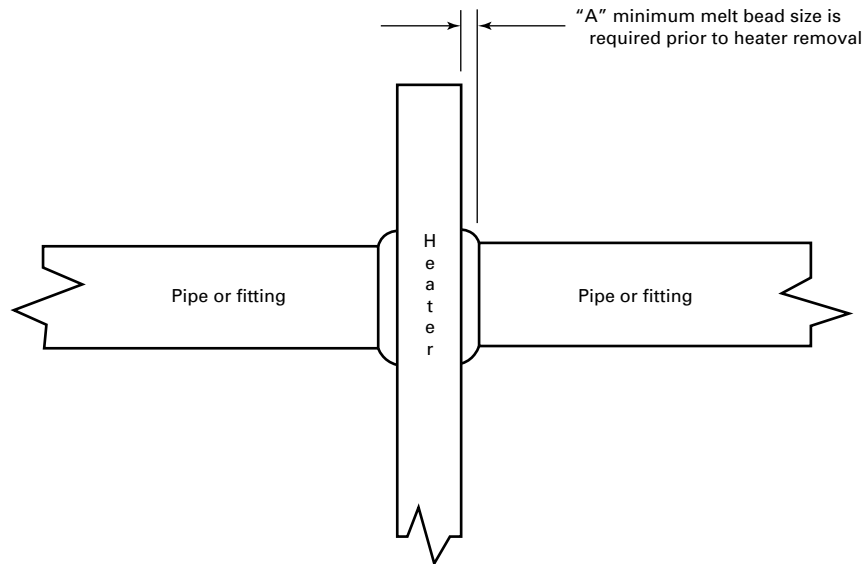


NPS	Center-to-End			NPS	Center-to-End		
	X	Y	Z		X	Y	Z
$\frac{1}{2} \times \frac{1}{2} \times \frac{3}{8}$	26.5 (1.04)	26.5 (1.04)	26.0 (1.03)	$\frac{1}{2} \times \frac{1}{4} \times 1$	42.0 (1.65)	40.0 (1.58)	45.5 (1.80)
$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{4}$	24.5 (0.97)	24.5 (0.97)	25.0 (0.98)	$\frac{1}{2} \times \frac{1}{4} \times \frac{3}{4}$	38.5 (1.52)	37.0 (1.45)	44.5 (1.75)
$\frac{3}{4} \times \frac{3}{4} \times \frac{1}{2}$	30.5 (1.20)	30.5 (1.20)	31.0 (1.22)	$\frac{1}{2} \times \frac{1}{4} \times \frac{1}{2}$	36.0 (1.41)	34.0 (1.34)	42.0 (1.66)
$\frac{3}{4} \times \frac{3}{4} \times \frac{3}{8}$	28.5 (1.12)	28.5 (1.12)	28.5 (1.13)	$\frac{1}{2} \times 1 \times \frac{1}{2}$	49.5 (1.94)	45.5 (1.80)	49.5 (1.94)
$\frac{3}{4} \times \frac{3}{4} \times \frac{1}{4}$	26.5 (1.05)	26.5 (1.05)	27.5 (1.08)	$\frac{1}{2} \times 1 \times \frac{1}{4}$	46.0 (1.82)	42.5 (1.67)	47.5 (1.88)
$\frac{3}{4} \times \frac{1}{2} \times \frac{3}{4}$	33.5 (1.31)	31.0 (1.22)	33.5 (1.31)	$\frac{1}{2} \times 1 \times 1$	42.0 (1.65)	38.0 (1.50)	45.5 (1.80)
$\frac{3}{4} \times \frac{1}{2} \times \frac{1}{2}$	30.5 (1.20)	28.5 (1.12)	31.0 (1.22)	$\frac{1}{2} \times \frac{3}{4} \times 1\frac{1}{2}$	49.5 (1.94)	44.5 (1.75)	49.5 (1.94)
$\frac{1}{2} \times \frac{1}{2} \times \frac{3}{4}$	31.0 (1.22)	31.0 (1.22)	30.5 (1.20)	$\frac{1}{2} \times \frac{3}{4} \times 1\frac{1}{4}$	46.0 (1.82)	41.0 (1.62)	48.0 (1.88)
$1 \times 1 \times \frac{3}{4}$	35.0 (1.37)	35.0 (1.37)	37.0 (1.45)	$\frac{1}{2} \times \frac{1}{2} \times 1\frac{1}{2}$	49.5 (1.94)	42.0 (1.66)	49.5 (1.94)
$1 \times 1 \times \frac{1}{2}$	32.0 (1.26)	32.0 (1.26)	35.5 (1.36)	$\frac{1}{4} \times \frac{1}{4} \times 1\frac{1}{2}$	48.0 (1.88)	48.0 (1.88)	46.0 (1.82)
$1 \times 1 \times \frac{3}{8}$	30.0 (1.18)	30.0 (1.18)	32.5 (1.27)	$\frac{1}{4} \times 1 \times 1\frac{1}{2}$	48.0 (1.88)	45.5 (1.80)	46.0 (1.82)
$1 \times \frac{3}{4} \times 1$	38.0 (1.50)	37.0 (1.45)	38.0 (1.50)	$1 \times 1 \times 1\frac{1}{2}$	45.5 (1.80)	45.5 (1.80)	42.0 (1.65)
$1 \times \frac{3}{4} \times \frac{3}{4}$	35.0 (1.37)	33.5 (1.31)	37.0 (1.45)	$2 \times 2 \times 1\frac{1}{2}$	51.5 (2.02)	51.5 (2.02)	55.0 (2.16)
$1 \times \frac{3}{4} \times \frac{1}{2}$	32.0 (1.26)	30.5 (1.20)	35.5 (1.36)	$2 \times 2 \times 1\frac{1}{4}$	48.5 (1.90)	48.5 (1.90)	53.5 (2.10)
$1 \times \frac{1}{2} \times 1$	38.0 (1.50)	35.5 (1.36)	38.0 (1.50)	$2 \times 2 \times 1$	44.0 (1.73)	44.0 (1.73)	51.5 (2.02)
$1 \times \frac{1}{2} \times \frac{3}{4}$	35.0 (1.37)	31.0 (1.22)	37.0 (1.45)	$2 \times 2 \times \frac{3}{4}$	40.5 (1.60)	40.5 (1.60)	50.0 (1.97)
$1 \times \frac{1}{2} \times \frac{1}{2}$	32.0 (1.26)	28.5 (1.12)	35.5 (1.36)	$2 \times 2 \times \frac{1}{2}$	38.0 (1.49)	38.0 (1.49)	48.0 (1.88)
$1 \times \frac{3}{8} \times 1$	38.0 (1.50)	32.5 (1.27)	38.0 (1.50)	$2 \times 1\frac{1}{2} \times 2$	57.0 (2.25)	55.0 (2.16)	57.0 (2.25)
$\frac{3}{4} \times \frac{3}{4} \times 1$	37.0 (1.45)	37.0 (1.45)	35.0 (1.37)	$2 \times 1\frac{1}{2} \times 1\frac{1}{2}$	51.5 (2.02)	49.5 (1.94)	55.0 (2.16)
$1\frac{1}{4} \times 1\frac{1}{4} \times 1$	40.0 (1.58)	40.0 (1.58)	42.5 (1.67)	$2 \times 1\frac{1}{2} \times 1\frac{1}{4}$	48.5 (1.90)	46.0 (1.82)	53.5 (2.10)
$1\frac{1}{4} \times 1\frac{1}{4} \times \frac{3}{4}$	37.0 (1.45)	37.0 (1.45)	41.0 (1.62)	$2 \times 1\frac{1}{2} \times 1$	44.0 (1.73)	42.0 (1.65)	51.5 (2.02)
$1\frac{1}{4} \times 1\frac{1}{4} \times \frac{1}{2}$	34.0 (1.34)	34.0 (1.34)	39.0 (1.53)	$2 \times 1\frac{1}{2} \times \frac{3}{4}$	40.5 (1.60)	38.5 (1.52)	50.0 (1.97)
$1\frac{1}{4} \times 1 \times 1\frac{1}{4}$	44.5 (1.75)	42.5 (1.67)	44.5 (1.75)	$2 \times 1\frac{1}{2} \times \frac{1}{2}$	38.0 (1.49)	36.0 (1.41)	48.0 (1.88)
$1\frac{1}{4} \times 1 \times 1$	40.0 (1.58)	38.0 (1.50)	42.5 (1.67)	$2 \times 1\frac{1}{4} \times 2$	57.0 (2.25)	53.5 (2.10)	57.0 (2.25)
$1\frac{1}{4} \times 1 \times \frac{3}{4}$	37.0 (1.45)	35.0 (1.37)	41.0 (1.62)	$2 \times 1\frac{1}{4} \times 1\frac{1}{2}$	51.5 (2.02)	48.0 (1.88)	55.0 (2.16)
$1\frac{1}{4} \times 1 \times \frac{1}{2}$	34.0 (1.34)	32.0 (1.26)	39.0 (1.53)	$2 \times 1\frac{1}{4} \times 1\frac{1}{4}$	48.5 (1.90)	44.5 (1.75)	53.5 (2.10)
$1\frac{1}{4} \times \frac{3}{4} \times 1\frac{1}{4}$	44.5 (1.75)	41.0 (1.62)	44.5 (1.75)	$2 \times 1\frac{1}{4} \times 1$	44.0 (1.73)	40.0 (1.58)	51.5 (2.02)
$1\frac{1}{4} \times \frac{3}{4} \times 1$	40.0 (1.58)	37.0 (1.45)	42.5 (1.67)	$2 \times 1 \times 2$	57.0 (2.25)	51.5 (2.02)	57.0 (2.25)
$1\frac{1}{4} \times \frac{3}{4} \times \frac{3}{4}$	37.0 (1.45)	33.5 (1.31)	41.0 (1.62)	$2 \times 1 \times 1\frac{1}{2}$	51.5 (2.02)	45.5 (1.80)	55.0 (2.16)
$1\frac{1}{4} \times \frac{1}{2} \times 1\frac{1}{4}$	44.5 (1.75)	39.0 (1.53)	44.5 (1.75)	$2 \times 1 \times 1\frac{1}{4}$	48.5 (1.90)	42.5 (1.67)	53.5 (2.10)
$1\frac{1}{4} \times \frac{1}{2} \times 1$	40.0 (1.58)	33.5 (1.36)	42.5 (1.67)	$2 \times \frac{3}{4} \times 2$	57.0 (2.25)	50.0 (1.97)	57.0 (2.25)
$1 \times 1 \times 1\frac{1}{4}$	42.5 (1.67)	42.5 (1.67)	40.0 (1.58)	$2 \times \frac{1}{2} \times 2$	57.0 (2.25)	48.0 (1.88)	57.0 (2.25)
$1\frac{1}{2} \times 1\frac{1}{2} \times 1\frac{1}{4}$	46.0 (1.82)	46.0 (1.82)	48.0 (1.88)	$1\frac{1}{2} \times 1 \times 2$	55.0 (2.16)	51.5 (2.02)	51.5 (2.02)
$1\frac{1}{2} \times 1\frac{1}{2} \times 1$	42.0 (1.65)	42.0 (1.65)	45.5 (1.80)	$1\frac{1}{4} \times 1\frac{1}{4} \times 2$	53.5 (2.10)	53.5 (2.10)	48.5 (1.90)
$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{4}$	38.5 (1.52)	38.5 (1.52)	44.5 (1.75)	$1\frac{1}{2} \times 1\frac{1}{2} \times 2$	55.0 (2.16)	55.0 (2.16)	51.5 (2.02)
$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{2}$	36.0 (1.41)	36.0 (1.41)	42.0 (1.66)	$1\frac{1}{2} \times 1\frac{1}{4} \times 2$	55.0 (2.16)	53.5 (2.10)	51.5 (2.02)
$1\frac{1}{2} \times 1\frac{1}{4} \times 1\frac{1}{2}$	49.5 (1.94)	47.5 (1.88)	49.5 (1.94)	$2\frac{1}{2} \times 2\frac{1}{2} \times 2$	60.5 (2.39)	60.5 (2.39)	66.0 (2.60)
$1\frac{1}{2} \times 1\frac{1}{4} \times 1\frac{1}{4}$	46.0 (1.82)	44.5 (1.75)	48.0 (1.88)	$2\frac{1}{2} \times 2\frac{1}{2} \times 1\frac{1}{2}$	55.0 (2.16)	55.0 (2.16)	64.0 (2.51)

Example SG4.4 Table Within a Figure

ASME NM.1-2020

Figure 5-2.6.1-1
Required Minimum Melt Bead Size



Pipe (O.D.), in. (mm)	"A" Minimum Melt Bead Size, in. (mm)
<2.37 (<60)	$\frac{1}{32}$ (1)
≥ 2.37 to ≤ 3.5 (≥ 6 to ≤ 89)	$\frac{1}{16}$ (1.5)
> 3.5 to ≤ 8.63 (> 89 to ≤ 219)	$\frac{3}{16}$ (5)
> 8.63 to ≤ 12.75 (> 219 to ≤ 324)	$\frac{1}{4}$ (6)
> 12.75 to ≤ 24 (> 324 to ≤ 610)	$\frac{3}{8}$ (10)
> 24 to ≤ 36 (> 610 to ≤ 900)	$\frac{7}{16}$ (11)
> 36 to ≤ 65 (> 900 to ≤ 1625)	$\frac{9}{16}$ (14)

(e) *Limitations.* Unfilled or unbonded areas in a joint, as indicated by the lack or interruption of the continuous fillet, are considered defects and shall be repaired and reexamined.

5-2.6.1 Butt Fusion

NOTE: The terms "hot plate" and "heated tool butt welding" are used to describe butt-fusion joining. Butt fusion is also called heat fusion.

Butt fusion procedure qualification shall include the following conditions:

(a) The axis of the pipe is limited to the horizontal position ± 45 deg.

(b) The pipe ends shall be faced to establish clean, parallel mating surfaces that are perpendicular to the pipe centerline on each pipe end, except for mitered joints.

(c) For mitered butt-fusion joints, the pipe faces shall be at the specific angle to produce the mitered joint.

(d) When the ends are brought together at the drag pressure, there shall be no visible gap.

(e) The external surfaces of the pipe shall be aligned to within 10% of the pipe wall thickness.

(f) Applied pressure during fusing shall meet the requirement of the FPS.

(g) The heater surface temperature shall meet the requirements of the FPS.

(h) The initial heating shall begin by inserting the heater into the gap between the pipe ends and applying the fusing pressure until an indication of melt is observed around the circumference of the pipe. When melt is observed, the pressure shall be reduced to drag pressure and the fixture shall be locked in position so that no outside force is applied to the joint during the heat soak cycle.

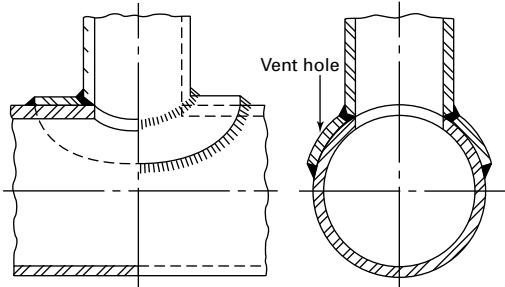
(i) The ends shall be held in place until the minimum bead size is formed between the heater faces and the pipe ends (see Figure 5-2.6.1-1).

(j) After the proper bead size is formed, the machine shall be opened, and the heater removed. The pipe end surfaces shall be smooth, flat, and free of contamination.

Example SG5.1 Figure Designator and Title

ASME B31.1-2022

**Figure 127.4.8-2
Typical Welded Branch Connection
With Additional Reinforcement**



136.4.1-1. For repairs to welds, the minimum examination shall be the same method that revealed the defect in the original weld. For repairs to base material, the minimum examination shall be the same as required for butt welds.

127.5 Qualification

127.5.1 General. Qualification of the WPS to be used, and of the performance of welders and welding operators, is required and shall comply with the requirements of ASME BPVC, Section IX, except as modified herein.

Certain materials listed in [Mandatory Appendix A](#) do not appear in ASME BPVC, Section IX P-Number groups. Where these materials have been assigned P-Numbers in [Mandatory Appendix A](#), they may be welded under this Code for nonboiler external piping only without separate qualification as if they were listed in ASME BPVC, Section IX.

127.5.2 Welding Responsibility. Each employer (see [para. 100.2](#)) shall be responsible for the welding performed by his/her organization and the performance of welders or welding operators employed by that organization.

127.5.3 Qualification Responsibility

(a) *Procedures.* Each employer shall be responsible for qualifying any WPS that he/she intends to have used by personnel of his/her organization. However, to avoid duplication of effort, and subject to approval of the owner, a WPS qualified by a technically competent group or agency may be used

(1) if the group or agency qualifying the WPS meets all of the procedure qualification requirements of this Code

(2) if the fabricator accepts the WPS thus qualified

(3) if the user of the WPS has qualified at least one welder using the WPS

(4) if the user of the WPS assumes specific responsibility for the procedure qualification work done for him/her by signing the records required by [para. 127.6](#)

All of the conditions in (1) through (4) shall be met before a WPS thus qualified may be used.

(b) *Welders and Welding Operators.* Each employer shall be responsible for qualifying all the welders and welding operators employed by him/her.

However, to avoid duplication of effort, he/she may accept a Welder/Welding Operator Performance Qualification (WPQ) made by a previous employer (subject to the approval of the owner or his/her agent) on piping using the same or an equivalent procedure wherein the essential variables are within the limits established in ASME BPVC, Section IX. An employer accepting such qualification tests by a previous employer shall obtain a copy of the original WPQ, showing the name of the employer by whom the welders or welding operators were qualified, the dates of such qualification, and evidence that the welder or welding operator has maintained qualification in accordance with ASME BPVC, Section IX, QW-322. The evidence of process usage to maintain continuity may be obtained from employers other than the original qualifying employer. The employer shall then prepare and sign the record required in [para. 127.6](#) accepting responsibility for the ability of the welder or welding operator.

127.5.4 Standard Welding Procedure Specifications.

Standard Welding Procedure Specifications published by the American Welding Society and listed in ASME BPVC, Section IX, Mandatory Appendix E are permitted for Code construction within the limitations established by ASME BPVC, Section IX, Article V.

127.6 Welding Records

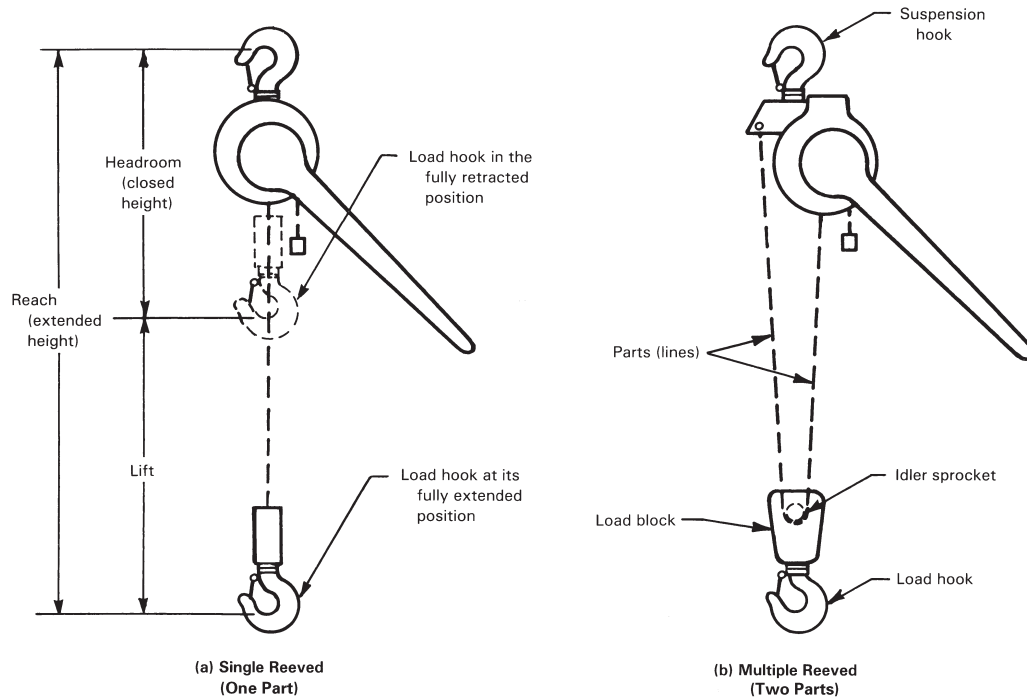
The employer shall maintain a record (WPS and/or WPQ) signed by him/her, and available to the purchaser or his/her agent and the inspector, of the WPSs used and the welders and/or welding operators employed by him/her, showing the date and results of procedure and performance qualification.

The WPQ shall also show the identification symbol assigned to the welder or welding operator employed by him/her, and the employer shall use this symbol to identify the welding performed by the welder or welding operator. This may be accomplished by the application of the symbol on the weld joint in a manner specified by the employer. Alternatively, the employer shall maintain records that identify welds made by the welder or welding operator.

Example SG5.2
Multi-Illustration Figure: Horizontal Presentation

ASME HST-3-2022

Figure 3-0.1-1
Lever Hoist

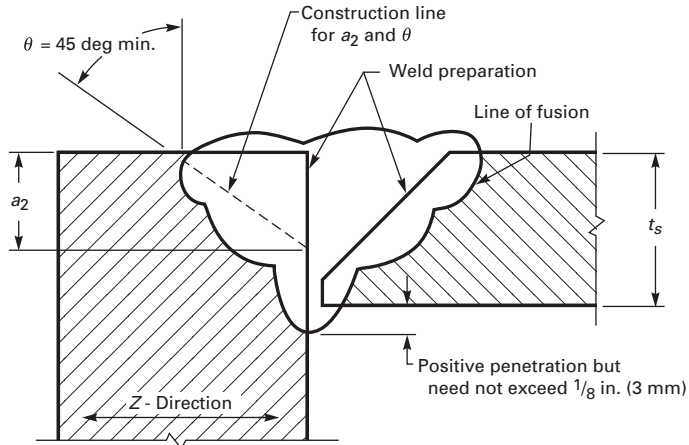


Example SG5.3
Multi-Illustration Figure: Vertical Presentation

ASME BPVC.VIII.1-2021

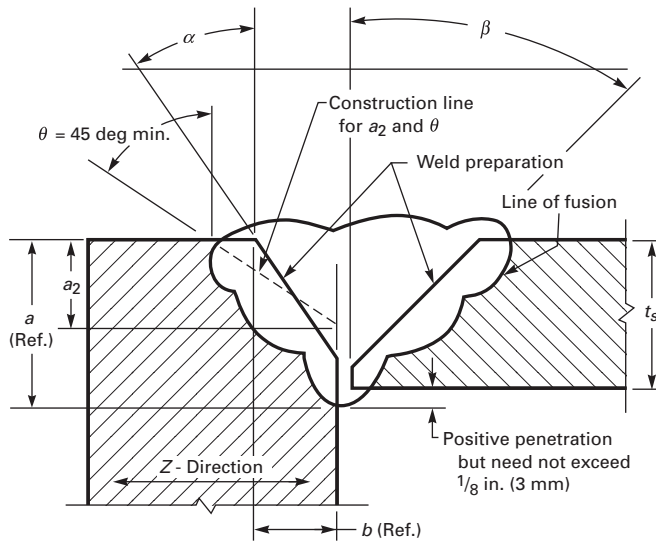
UW-13

Figure UW-13.2
Attachment of Pressure Parts to Flat Plates to Form a Corner Joint (Cont'd)



K	a_2/t_s Not Less Than
0.6	0.29
0.7	0.23
0.8	0.17
0.9	0.09
1.0	0

(r) Details for One Member Beveled [See Note (3)]



K	Min. a_2/t_s for α Not Less Than 15 deg	Min. a_2/t_s for α Not Less Than 30 deg	Min. a_2/t_s for α Not Less Than 45 deg
0.6	0.85	0.55	0.29
0.7	0.81	0.47	0.23
0.8	0.74	0.38	0.17
0.9	0.58	0.23	0.09
1.0	0	0	0

See sketch (r) above for table with values of K and a_2/t_s

(s) Details for Both Members Beveled [See Note (3)]

GENERAL NOTES:

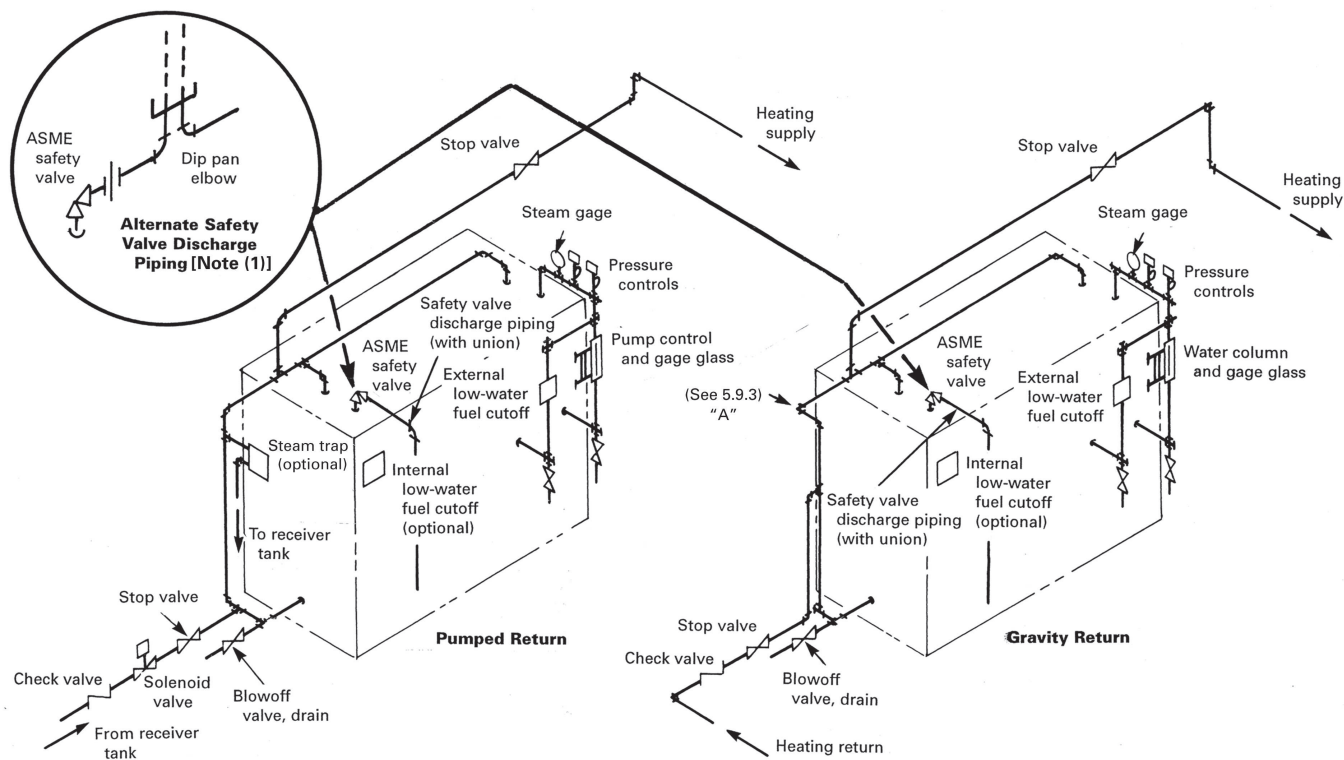
- (a) $a + b$ not less than $2t_s$; c not less than $0.7t_s$ or $1.4t_r$, whichever is less.
- (b) t_s and t_r are as defined in [UG-34\(b\)](#).
- (c) Dimension b is produced by the weld preparation and shall be verified after fit up and before welding.

NOTES:

- (1) For unstayed flat heads, see also [UG-34](#).
- (2) c , t_n , and t_s are as defined in [2-3](#).
- (3) Interpolation of α and K is permitted.

Example SG5.4 Landscaped Figure

Figure 5.9.1-3
Single Steam Boilers — Acceptable Piping Installation



GENERAL NOTES:

- Plumbing codes may require the installation of a reduced-pressure principle backflow preventer on a boiler when the makeup water source is from a potable water supply.
- Return loop connection was designed to eliminate the necessity of check valves on gravity return systems, but in some localities a check valve is a legal requirement.
- When pump discharge piping exceeds 25 ft (7.6 m), install swing check valves at pump discharge.
- If pump discharge is looped above normal boiler waterline, install a spring-loaded check valve at return header and at pump discharge.
- Where supply pressures are adequate, makeup water may be introduced directly to a boiler through an independent connection.

NOTE: (1) Recommended for 1-in. (25-mm) and larger safety valve discharge.

Example SG5.6 Non-ASME BPVC Form

ASME HST-4-2021

Form 4-4.1-1 Typical Electric Wire Rope Hoist and Trolley Inquiry Data Form

HOIST

Quantity required _____
 Rated load _____ tons (_____ kg)
 Lift [Note (1)] _____ ft (_____ m)
 Reach _____ ft (_____ m)
 Headroom _____ in. (_____ mm)
 Distance from operating floor to underside of beam or
 to support point:
 _____ ft _____ in. (_____ m)
 Hoisting speed _____ ft/min (_____ m/min)

Type of control:

☐ Single speed ☐ Two speed
☐ Variable speed ☐ Other _____

POWER SUPPLY

Voltage	Phase	Hertz	Control voltage
☐ 230	3	60	☐ 24
☐ 460	3	60	☐ 115
☐ 575	3	60	☐ Other _____
☐ 115	1	60	
☐ 230	1	60	
☐ _____	_____	_____ Other	

Performance Requirements (see Chapter 4-1 and
 Nonmandatory Appendix B):

Average lift _____ ft (_____ m)
 Number of lifts/hr _____
 Number of starts/hr _____
 Work period hr/day _____
 Hoist service classification H _____

Furnish complete information regarding any abnormal
 operating conditions. For hazardous locations, identify
 location classification as specified in NFPA 70, if
 applicable, and additional information that may impact
 a spark-resistance assessment: _____

Type of suspension:

☐ Lug ☐ Hook ☐ Clevis
☐ Plain trolley ☐ Hand-chain-operated trolley
☐ Motor-driven trolley ☐ Other _____

TROLLEY

Travel speed _____ ft/min (_____ m/min)
☐ Trolley brake required

Type of control:

☐ Single speed ☐ Two speed
☐ Cushioned start ☐ Variable speed
☐ Other _____

Type and size of beam _____

Width of running flange _____ in. (_____ mm)

Minimum radius of beam curves
 _____ ft _____ in. (_____ m)

Clearance dimensions of interlocks, switches, or beam
 splices (if used): _____

Current conductor system (if required):

☐ Tagline ☐ Festooned cable
☐ Cable reel ☐ Conductor-collector system
☐ Other _____

Type of conductors (make or manufacturer) _____

Location of conductors on beam (use sketch if
 necessary) _____

OPTIONAL EQUIPMENT REQUIRED

NOTE: (1) Refer to the manufacturer's catalog for standard lift that will meet the application requirement.

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