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**Subtitle:**........ 33

**Scope:** This article covers the mandatory design rules for Class II vessels, providing guidelines on various aspects such as loadings, design limitations, and loadings. It also includes sections on specific components like threaded openings, manhole cover plates, and actuating closures. The content is structured to ensure compliance with the design criteria for Class II vessels, ensuring safety and integrity during operation.
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VII Recommended Guidelines for the Care of Power Boilers

VIII Rules for Construction of Pressure Vessels
  • Division 1
  • Division 2 — Alternative Rules
  • Division 3 — Alternative Rules for Construction of High Pressure Vessels

IX Welding, Brazing, and Fusing Qualifications

X Fiber-Reinforced Plastic Pressure Vessels

XI Rules for Inservice Inspection of Nuclear Power Plant Components

XII Rules for Construction and Continued Service of Transport Tanks

* The 2015 Edition of Section III is the last edition in which Section III, Division 1, Subsection NH, Class 1 Components in Elevated Temperature Service, will be published. The requirements located within Subsection NH have been moved to Section III, Division 5, Subsection HB, Subpart B for the elevated temperature construction of Class A components.
INTERPRETATIONS

Interpretations of the Code have historically been posted in January and July at http://cstools.asme.org/interpretations.cfm. Interpretations issued during the previous two calendar years are included with the publication of the applicable Section of the Code in the 2015 Edition. Interpretations of Section III, Divisions 1 and 2 and Section III Appendices are included with Subsection NCA.

Following the 2015 Edition, interpretations will not be included in editions; they will be issued in real time in ASME’s Interpretations Database at http://go.asme.org/Interpretations. Historical BPVC interpretations may also be found in the Database.

CODE CASES

The Boiler and Pressure Vessel Code committees meet regularly to consider proposed additions and revisions to the Code and to formulate Cases to clarify the intent of existing requirements or provide, when the need is urgent, rules for materials or constructions not covered by existing Code rules. Those Cases that have been adopted will appear in the appropriate 2015 Code Cases book: "Boilers and Pressure Vessels" or "Nuclear Components." Supplements will be sent or made available automatically to the purchasers of the Code Cases books up to the publication of the 2017 Code.
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) 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 only 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 judgement 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

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*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 pressure relief.
requirements of the Code. However, designers and engineers using computer programs for design or analysis are cau-
tioned that they are responsible for all technical assumptions inherent in the programs they use and the application of these programs to their design.

The rules established by the Committee are not to be interpreted as approving, recommending, or endorsing any pro-
prietary or specific design, or as limiting in any way the manufacturer’s freedom to choose any method of design or any form of construction that conforms to the Code rules.

The Committee meets regularly to consider revisions of the rules, new rules as dictated by technological development, Code Cases, and requests for interpretations. Only the Committee has the authority to provide official interpretations of this Code. Requests for revisions, new rules, Code Cases, or interpretations shall be addressed to the Secretary in writing and shall give full particulars in order to receive consideration and action (see Submittal of Technical Inquiries to the Boiler and Pressure Vessel Standards Committees). Proposed revisions to the Code resulting from inquiries will be pre-

sented to the Committee for appropriate action. The action of the Committee becomes effective only after confirmation by ballot of the Committee and approval by ASME. Proposed revisions to the Code approved by the Committee are sub-
mitted to the American National Standards Institute (ANSI) and published at http://go.asme.org/BPVCPublicReview to invite comments from all interested persons. After public review and final approval by ASME, revisions are published at regular intervals in Editions of the Code.

The Committee does not rule on whether a component shall or shall not be constructed to the provisions of the Code. The scope of each Section has been established to identify the components and parameters considered by the Committee in formulating the Code rules.

Questions or issues regarding compliance of a specific component with the Code rules are to be directed to the ASME Certificate Holder (Manufacturer). Inquiries concerning the interpretation of the Code are to be directed to the Commit-
tee. ASME is to be notified should questions arise concerning improper use of an ASME Certification Mark.

When required by context in this Section, the singular shall be interpreted as the plural, and vice versa, and the fem-
ine, masculine, or neuter gender shall be treated as such other gender as appropriate.
STATEMENT OF POLICY ON THE USE OF THE CERTIFICATION MARK AND CODE AUTHORIZATION IN ADVERTISING

ASME has established procedures to authorize qualified organizations to perform various activities in accordance with the requirements of the ASME Boiler and Pressure Vessel Code. It is the aim of the Society to provide recognition of organizations so authorized. An organization holding authorization to perform various activities in accordance with the requirements of the Code may state this capability in its advertising literature.

Organizations that are authorized to use the Certification Mark for marking items or constructions that have been constructed and inspected in compliance with the ASME Boiler and Pressure Vessel Code are issued Certificates of Authorization. It is the aim of the Society to maintain the standing of the Certification Mark for the benefit of the users, the enforcement jurisdictions, and the holders of the Certification Mark who comply with all requirements.

Based on these objectives, the following policy has been established on the usage in advertising of facsimiles of the Certification Mark, Certificates of Authorization, and reference to Code construction. The American Society of Mechanical Engineers does not "approve," "certify," "rate," or "endorse" any item, construction, or activity and there shall be no statements or implications that might so indicate. An organization holding the Certification Mark and/or a Certificate of Authorization may state in advertising literature that items, constructions, or activities "are built (produced or performed) or activities conducted in accordance with the requirements of the ASME Boiler and Pressure Vessel Code," or "meet the requirements of the ASME Boiler and Pressure Vessel Code." An ASME corporate logo shall not be used by any organization other than ASME.

The Certification Mark shall be used only for stamping and nameplates as specifically provided in the Code. However, facsimiles may be used for the purpose of fostering the use of such construction. Such usage may be by an association or a society, or by a holder of the Certification Mark who may also use the facsimile in advertising to show that clearly specified items will carry the Certification Mark. General usage is permitted only when all of a manufacturer’s items are constructed under the rules.

STATEMENT OF POLICY ON THE USE OF ASME MARKING TO IDENTIFY MANUFACTURED ITEMS

The ASME Boiler and Pressure Vessel Code provides rules for the construction of boilers, pressure vessels, and nuclear components. This includes requirements for materials, design, fabrication, examination, inspection, and stamping. Items constructed in accordance with all of the applicable rules of the Code are identified with the official Certification Mark described in the governing Section of the Code.

Markings such as "ASME," "ASME Standard," or any other marking including "ASME" or the Certification Mark shall not be used on any item that is not constructed in accordance with all of the applicable requirements of the Code.

Items shall not be described on ASME Data Report Forms nor on similar forms referring to ASME that tend to imply that all Code requirements have been met when, in fact, they have not been. Data Report Forms covering items not fully complying with ASME requirements should not refer to ASME or they should clearly identify all exceptions to the ASME requirements.
1 INTRODUCTION

(a) The following information provides guidance to Code users for submitting technical inquiries to the committees. See Guideline on the Approval of New Materials Under the ASME Boiler and Pressure Vessel Code in Section II, Parts C and D for additional requirements for requests involving adding new materials to the Code. Technical inquiries include requests for revisions or additions to the Code rules, requests for Code Cases, and requests for Code Interpretations, as described below.

(1) Code Revisions. Code revisions are considered to accommodate technological developments, address administrative requirements, incorporate Code Cases, or to clarify Code intent.

(2) Code Cases. Code Cases represent alternatives or additions to existing Code rules. Code Cases are written as a question and reply, and are usually intended to be incorporated into the Code at a later date. When used, Code Cases prescribe mandatory requirements in the same sense as the text of the Code. However, users are cautioned that not all jurisdictions or owners automatically accept Code Cases. The most common applications for Code Cases are:
   (-a) to permit early implementation of an approved Code revision based on an urgent need
   (-b) to permit the use of a new material for Code construction
   (-c) to gain experience with new materials or alternative rules prior to incorporation directly into the Code

(3) Code Interpretations. Code Interpretations provide clarification of the meaning of existing rules in the Code, and are also presented in question and reply format. Interpretations do not introduce new requirements. In cases where existing Code text does not fully convey the meaning that was intended, and revision of the rules is required to support an interpretation, an Intent Interpretation will be issued and the Code will be revised.

(b) The Code rules, Code Cases, and Code Interpretations established by the committees 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 rules.

(c) Inquiries that do not comply with these provisions or that do not provide sufficient information for a committee’s full understanding may result in the request being returned to the inquirer with no action.

2 INQUIRY FORMAT

Submittals to a committee shall include:

(a) Purpose. Specify one of the following:
   (1) revision of present Code rules
   (2) new or additional Code rules
   (3) Code Case
   (4) Code Interpretation

(b) Background. Provide the information needed for the committee’s understanding of the inquiry, being sure to include reference to the applicable Code Section, Division, edition, addenda (if applicable), paragraphs, figures, and tables. Preferably, provide a copy of the specific referenced portions of the Code.

(c) Presentations. The inquirer may desire or be asked to attend a meeting of the committee to make a formal presentation or to answer questions from the committee members with regard to the inquiry. Attendance at a committee meeting shall be at the expense of the inquirer. The inquirer’s attendance or lack of attendance at a meeting shall not be a basis for acceptance or rejection of the inquiry by the committee.
3 CODE REVISIONS OR ADDITIONS

Requests for Code revisions or additions shall provide the following:

(a) Proposed Revisions or Additions. For revisions, identify the rules of the Code that require revision and submit a copy of the appropriate rules as they appear in the Code, marked up with the proposed revision. For additions, provide the recommended wording referenced to the existing Code rules.

(b) Statement of Need. Provide a brief explanation of the need for the revision or addition.

(c) Background Information. Provide background information to support the revision or addition, including any data or changes in technology that form the basis for the request that will allow the committee to adequately evaluate the proposed revision or addition. Sketches, tables, figures, and graphs should be submitted as appropriate. When applicable, identify any pertinent paragraph in the Code that would be affected by the revision or addition and identify paragraphs in the Code that reference the paragraphs that are to be revised or added.

4 CODE CASES

Requests for Code Cases shall provide a Statement of Need and Background Information similar to that defined in 3(b) and 3(c), respectively, for Code revisions or additions. The urgency of the Code Case (e.g., project underway or imminent, new procedure, etc.) must be defined and it must be confirmed that the request is in connection with equipment that will bear the Certification Mark, with the exception of Section XI applications. The proposed Code Case should identify the Code Section and Division, and be written as a Question and a Reply in the same format as existing Code Cases. Requests for Code Cases should also indicate the applicable Code editions and addenda (if applicable) to which the proposed Code Case applies.

5 CODE INTERPRETATIONS

(a) Requests for Code Interpretations shall provide the following:

(1) Inquiry. Provide a condensed and precise question, omitting superfluous background information and, when possible, composed in such a way that a “yes” or a “no” Reply, with brief provisos if needed, is acceptable. The question should be technically and editorially correct.

(2) Reply. Provide a proposed Reply that will clearly and concisely answer the Inquiry question. Preferably, the Reply should be “yes” or “no,” with brief provisos if needed.

(3) Background Information. Provide any background information that will assist the committee in understanding the proposed Inquiry and Reply.

(b) Requests for Code Interpretations must be limited to an interpretation of a particular requirement in the Code or a Code Case. The committee cannot consider consulting type requests such as the following:

(1) a review of calculations, design drawings, welding qualifications, or descriptions of equipment or parts to determine compliance with Code requirements;

(2) a request for assistance in performing any Code-prescribed functions relating to, but not limited to, material selection, designs, calculations, fabrication, inspection, pressure testing, or installation;

(3) a request seeking the rationale for Code requirements.

6 SUBMITTALS

Submittals to and responses from the committees shall meet the following:

(a) Submittal. Inquiries from Code users shall be in English and preferably be submitted in typewritten form; however, legible handwritten inquiries will also be considered. They shall include the name, address, telephone number, fax number, and e-mail address, if available, of the inquirer and be mailed to the following address:

Secretary
ASME Boiler and Pressure Vessel Committee
Two Park Avenue
New York, NY 10016-5990

As an alternative, inquiries may be submitted via e-mail to: SecretaryBPV@asme.org or via our online tool at http://go.asme.org/InterpretationRequest.

(b) Response. The Secretary of the appropriate committee shall acknowledge receipt of each properly prepared inquiry and shall provide a written response to the inquirer upon completion of the requested action by the committee.
PERSONNEL
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January 1, 2015

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M. Mailman — Northwest Territories, Canada

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Y.-W. Park
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P. Williamson

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L. C. Leet — Washington
A. M. Lorimor — South Dakota
M. Mailman — Northwest Territories, Canada

C. Minu
T. S. G. Narayannen
Y.-W. Park
R. Reynaga
P. Williamson

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### COMMITTEE ON POWER BOILERS (BPV I)

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<th>Chair</th>
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### Subgroup on Design (BPV I)

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### Subgroup on Fabrication and Examination (BPV I)

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### Subgroup on General Requirements and Piping (BPV I)

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### Subgroup on Heat Recovery Steam Generators (BPV I)

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### Subgroup on Materials (BPV I)

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### India International Working Group (BPV I)

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### Task Group on Modernization of BPVC Section I

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<th>Secretary</th>
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Working Group on Creep Strength Enhanced Ferritic Steels (BPV II)

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D. A. Canonic0
K. K. Coleman
G. Cumino
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D. P. Munson
F. J. Schaaf, Jr.
R. Stakenborgs
H. E. Svetlik
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<th>Working Group on Piping (SG-CD) (BPV III)</th>
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<td>S. McKillop, Secretary</td>
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R. B. Patel
E. C. Renaud
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S. Patterson
S. Schuessler
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M. F. Hessheimer, Contributing Member
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D. Ufuk
J. B. Domage
Z. Shang
M. Diaz
M. F. Hessheimer
J. Munshi
A. Istar
T. E. Johnson
B. R. Laskewitz
M. Sircar

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C. Jones
M. Diaz
S. Wang
M. A. Ugalde
S. Alchaar
J.-B. Domage
U. Ricklefs

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M. Lashley
T. Melfi
H. Murakami
J. Ossmann
J. E. O'Sullivan
C. Pearce
N. M. Simpson
W. J. Sperko
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J. F. Strunk
K. B. Stuckey
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S.-H. Chi
A. Covac
M. W. Davies
S. W. Doms
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S. T. Gonczy
M. G. Jenkins
Y. Katoh
M. N. Mitchell
J. Ossmann
M. Roemmeler
N. Salstrom
T. Shibata
S. Yee
G. L. Zeng

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A. C. Eberhardt
T. J. Ahl
A. Byk
J. F. Artuso
J. B. Domage
A. C. Eberhardt
C. Jones
M. Diaz
M. F. Hessheimer
A. Istar
T. E. Johnson
B. R. Laskewitz
Z. Shang
M. Sircar

Special Working Group on Modernization (BPV III-2)

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A. Adediran
N. Alchaar
O. Jovall
C. T. Smith
M. Diaz
S. Wang
M. A. Ugalde
S. Alchaar
U. Ricklefs

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Subgroup on Containment Systems for Spent Fuel and High-Level Waste Transport Packagings (BPV III)

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G. M. Foster, Vice Chair  
G. R. Cannell, Secretary  
G. Abramczyk  
D. J. Ammerman  
G. Bjorkman  
F. Horowitz  
D. W. Lewis  
P. E. McConnell  
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<td>R. L. Dyle</td>
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<td>M. J. Ferlisi</td>
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<td>W. E. Norris</td>
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<td>G. L. Stevens</td>
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<td>R. W. Swayne</td>
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<table>
<thead>
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### Working Group on Personnel Qualification and Surface Visual and Eddy Current Examination (SG-NDE) (BPV XI)

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INTRODUCTION

1 GENERAL

The use of fiber-reinforced plastics for the manufacture of pressure vessels presents unique materials considerations in the design, fabrication, and testing of these vessels. Metallic vessels, being made from materials which are normally isotropic and ductile, are designed by using well-established allowable stresses based on measured tensile and ductility properties. In contrast, fiber-reinforced plastics are usually anisotropic and the physical properties are dependent upon the fabrication process, the placement and orientation of the reinforcement, and the resin matrix. It is the purpose of this Introduction to describe in a general way the criteria that were used in preparing Section X, Fiber-Reinforced Plastic Pressure Vessels. A list of standards referenced in this Section is provided in Table 1.1.

2 MATERIALS

It is not possible to fabricate a reinforced plastic pressure vessel of a single basic material for which there is an ASTM specification. The vessel parts are made up of various basic materials, such as fiber reinforcement and resin, which are joined in the presence of a catalyst to create a composite material that is formed into a vessel or vessel part by a specified process. The composite material will often have directional properties which shall be considered in design. General specifications for the basic materials (fiber reinforcement and resin) are stated, as are requirements for determination of elastic properties for the composite material (laminate) produced. Elastic properties of specific laminates used in vessel fabrication are required when mandatory rules are used for vessel design. Metallic materials, when used in conjunction with reinforced fiber laminates, are required to meet ASME Boiler and Pressure Vessel Code specifications, Section VIII, Division 1. That Section must be used for the design, fabrication, quality control, and inspection of such metallic parts. However, for hydrostatic leakage testing, these metallic materials that complete the vessel are required to meet Section X requirements.

3 DESIGN

3.1 GENERAL

3.1.1 Adequacy of specific designs shall be qualified by one of the following methods:1

(a) Class I Design — qualification of a vessel design through the pressure testing of a prototype.

(b) Class II Design — mandatory design rules and acceptable testing by nondestructive methods.

(c) Class III Design — qualification of a vessel design through the pressure testing of a prototype, other specified tests of prototypes, mandatory design rules and acceptance testing by nondestructive methods.

3.1.2 Class I designs based on the qualification of a prototype vessel require that the minimum qualification pressure of the prototype be at least six2 times the design pressure. The maximum design pressure is limited to 150 psi (1 MPa) for bag-molded, centrifugally cast, and contact-molded vessels; 1,500 psi (10 MPa) for filament-wound vessels; and 3,000 psi (20 MPa) for filament-wound vessels with polar boss openings.

3.1.3 Class II designs based on mandatory design rules and acceptance testing must comply with Article RD-11 and Article RT-6. The maximum design pressure allowed under this procedure shall be as specified in RD-1120.

3.1.4 Class III designs include the qualification of a prototype with the minimum qualification pressure of the prototype to be at 2.25 times the design pressure for carbon fiber vessels, and 3.5 times the design pressure for glass fiber vessels. Hybrid designs using more than one type of fiber are covered in 8-400.7. The maximum design pressure is limited to 15,000 psi (103 MPa). The minimum design pressure shall be not less than 3,000 psi (20.7 MPa).

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1 These three methods shall not be intermixed.

2 An exception to this six times factor is applicable to vessels per (Filament Winding — Polar Boss Openings Only).
### Table 1.1

**Referenced Standards in This Section**

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<td>ASME B16.5</td>
<td>1996</td>
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<td>Conformity Assessment Requirements</td>
<td>ASME CA-1</td>
<td>Latest edition</td>
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<tr>
<td>Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement</td>
<td>ASTM D792</td>
<td>2000</td>
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<tr>
<td>Standard Test Method for Apparent Interlaminar Shear Strength of Parallel Fiber Composites by Short-Beam Method</td>
<td>ASTM D2344</td>
<td>2000</td>
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<tr>
<td>Standard Test Method for Epoxy Resins and Related Components</td>
<td>ASTM D2393</td>
<td>1986</td>
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<tr>
<td>Standard Test Method for Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins</td>
<td>ASTM D2471</td>
<td>1999</td>
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<tr>
<td>Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings</td>
<td>ASTM D2992</td>
<td>2001</td>
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<tr>
<td>Standard Test Method for Fiber Content of Resin-Matrix Composite by Matrix Digestion</td>
<td>ASTM D3171</td>
<td>1999</td>
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<tr>
<td>Standard Test Method for In-Plane Shear Strength of Reinforced Plastics</td>
<td>ASTM D3846</td>
<td>2002</td>
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<tr>
<td>Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing</td>
<td>SNT-TC-1A</td>
<td>1992</td>
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**GENERAL NOTES:**

(a) The number following the standard indicates the year of original adoption, or in the case of revision, the year of the last revision. A number in parentheses indicates the year of last approval.

(b) Additional standards referenced for Class III vessels are listed in 8-200.4.
3.2 LOW MODULUS CHARACTERISTICS

Fiber-reinforced plastic laminates may have a modulus of elasticity as low as \(1.0 \times 10^6\) psi (6 900 MPa), compared with that of ferrous materials which may be of the order of \(30 \times 10^6\) psi (2.1 × 10^5 MPa). This low modulus characteristic requires careful consideration of vessel profile in order to minimize bending and avoid buckling. Spherical heads or elliptical heads having an ellipse ratio not greater than 2:1 are suggested. Spherical heads are suggested when the material has isotropic properties. Elliptical heads are preferred when the material has anisotropic properties.

3.3 FATIGUE

3.3.1 Like metallic materials, the composite material (laminate) of fiber-reinforced plastic vessels, when stressed at sufficiently low levels, exhibits good fatigue life. However, its low modulus of elasticity provides a higher strain per unit of stress than metals used for metallic vessels.

3.3.2 Section X, therefore, requires that a Class I design that is qualified by testing of a prototype vessel be pressure cycled 100,000 times over a pressure range of atmospheric to the design pressure; after this, the test vessel must withstand a hydrostatic qualification test not less than six times the design pressure. An exception to this 100,000 cycle requirement is applicable to vessels per RG-404.2 (Filament Winding — Polar Boss Openings Only). That classification of vessels is designed for a 5:1 factor of safety which requires cycling from atmospheric to the design pressure for 33,000 cycles; after this, the test vessel must withstand a hydrostatic qualification test not less than five times the design pressure.

3.3.3 Class II vessels qualified using mandatory design rules and acceptance testing are not required to be subjected to the above cyclic and qualification pressure test criteria.

3.3.4 Section X requires that a Class III design qualification include testing of a prototype vessel that is pressure cycled for “N” cycles as prescribed in 8-700.5.4.1 over a pressure range of 10% of design pressure to 100% of design pressure without leakage or rupture; then followed by additional cycles until the vessel leaks or a total of 2 times “N” cycles have been reached.

3.4 CREEP, STRESS-RUPTURE, AND TEMPERATURE EFFECTS

Fiber-reinforced plastic composite material (laminate) is not subject to creep or failure due to low stress-to-rupture characteristics as are some other materials. The material does, however, lose ultimate strength as the temperature is increased and gains strength but becomes more brittle as the temperature is lowered. Its low thermal conductivity and ablative properties are other factors significantly affecting the behavior of this material in the event of fire or other high-temperature environment. The maximum design, operating, and test temperatures of Class I vessels are set as follows:

(a) 150°F (65°C) for design temperatures less than or equal to 150°F (65°C);
(b) 250°F (120°C) or to within 35°F (19°C) of the glass transition temperature (whichever is lower) for design temperatures in excess of 150°F (65°C).

The maximum design, operating, and test temperatures of Class II vessels are limited to an inside wall temperature of 250°F (120°C) or to within 35°F (19°C) of the glass transition temperature of the resin (whichever is lower). The maximum design temperature of Class III vessels shall be 35°F (19°C) below the maximum use temperature of the resin as documented in the Manufacturing Specifications, but in no case shall it exceed 185°F (85°C). The minimum design temperature of Class I, Class II, and Class III vessels shall be −65°F (−54°C) (see RD-112).

3.5 FABRICATION

3.5.1 Many processes are used in the fabrication of fiber-reinforced composite materials (laminates). Class I vessels are limited to four processes, namely, filament winding, bag molding, contact molding, and centrifugal casting. Class II vessels are limited to two processes, namely, filament winding and contact molding.

3.5.2 The fabrication of more than one Class I vessel may be required to comply with the requirements for qualifying a design using the prototype vessel method. Once a specific design has been qualified, the quality of subsequent vessels of the same dimension and design is to be assured by carefully controlled fabrication procedures and rigid Quality Control Programs.

3.5.3 Every Class II vessel must be acceptance tested as specified in Article RT-6. Such tests must be documented as having met the acceptance criteria of Article RT-6 and shall become part of the Fabricator’s Design Report.

3.5.4 Class III vessels are limited to filament-wound construction with polar loss openings.

Prototype vessels used to qualify a design shall not be stamped with the Certification Mark.

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3.6 INSPECTION

3.6.1 The general philosophy of Section VIII, Division 1, regarding inspection during fabrication is continued in this Section. Familiarity with the laminate production processes and the nature of vessel imperfections is required of the Inspector. Reliance is placed upon careful auditing of the Fabricator’s Quality Control Program, close visual inspection of completed vessels by both Fabricator personnel and the Inspector, and acceptance testing where required by this Section.

3.6.2 This Section requires that all laminate and secondary bonding work be without use of pigments, fillers, or resin putty mixtures except as permitted by the Procedure Specification used in fabricating the vessel or vessel part.

3.7 LINERS

Liners may be used in Section X vessels as a barrier between the laminate and the vessel contents. Such liners shall not be considered part of the structural component of the vessel.

3.8 UNITS

3.8.1 Either U.S. Customary, SI, or any local customary units may be used to demonstrate compliance with all requirements of this Edition (e.g., materials, design, fabrication, examination, inspection, testing, certification, and overpressure protection).

3.8.2 In general, it is expected that a single system of units shall be used for all aspects of design except where unfeasible or impractical. When components are manufactured at different locations where local customary units are different than those used for the general design, the local units may be used for the design and documentation of that component. Similarly, for proprietary components or those uniquely associated with a system of units different than that used for the general design, the alternate units may be used for the design and documentation of that component.

3.8.3 For any single equation, all variables shall be expressed in a single system of units. When separate equations are provided for U.S. Customary units and SI units, those equations must be executed using variables in the units associated with the specific equation. Data expressed in other units shall be converted to U.S. Customary units or SI units for use in these equations. The result obtained from execution of these equations may be converted to other units.

3.8.4 Production, measurement and test equipment, drawings, welding procedure specifications, welding procedure and performance qualifications, and other fabrication documents may be in U.S. Customary, SI, or local customary units in accordance with the fabricator’s practice. When values shown in calculations and analysis, fabrication documents, or measurement and test equipment are in different units, any conversions necessary for verification of Code compliance and to ensure that dimensional consistency is maintained, shall be in accordance with the following:

(a) Conversion factors shall be accurate to at least four significant figures.

(b) The results of conversions of units shall be expressed to a minimum of three significant figures.

3.8.5 Material that has been manufactured and certified to either the U.S. Customary or SI material specification (e.g., SA-516M) may be used regardless of the unit system used in design. Standard fittings (e.g., flanges, elbows, etc.) that have been certified to either U.S. Customary units or SI units may be used regardless of the units system used in design.

3.8.6 Conversion of units, using the precision specified in para. 20, shall be performed to assure that dimensional consistency is maintained. Conversion factors between U.S. Customary units and SI units may be found in the Nonmandatory Appendix, Guidance for the Use of U.S. Customary and SI units in the ASME Boiler and Pressure Vessel Code. Whenever local customary units are used, the Manufacturer shall provide the source of the conversion factors which shall be subject to verification and acceptance by the Authorized Inspector or Certified Individual.

3.8.7 All entries on a Manufacturer’s Data Report and data for Code required nameplate marking shall be in units consistent with the fabrication drawings for the component using U.S. Customary, SI, or local customary units. It is acceptable to show alternate units parenthetically. Users of this Code are cautioned that the receiving Jurisdiction should be contacted to ensure the units are acceptable.
**SUMMARY OF CHANGES**

After publication of the 2015 Edition, Errata to the BPV Code may be posted on the ASME Web site to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in the BPV Code. Such Errata shall be used on the date posted.

Information regarding Special Notices and Errata is published by ASME at http://go.asme.org/BPVCerrata.

Changes given below are identified on the pages by a margin note, (15), placed next to the affected area.

The Record Numbers listed below are explained in more detail in "List of Changes in Record Number Order" following this Summary of Changes.

<table>
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<tr>
<th>Page Location Change (Record Number)</th>
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<tr>
<td>xi List of Sections Revised (13-666)</td>
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<tr>
<td>xiii Foreword (1) Revised (2) New footnote added by errata (13-860)</td>
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<tr>
<td>xvi Submittal of Technical Inquiries to the Boiler and Pressure Vessel Standards Committees In last line of 6(a), URL revised</td>
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<td>xviii Personnel Updated (13-666)</td>
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<td>xxxvi Table 1.1 Reference to ASME CA-1 added (13-666)</td>
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<td>38 Figure RD-1174.2 Callouts revised (14-643)</td>
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<td>51 RD-1188.5 Equations (16) and (18) revised (14-643)</td>
</tr>
<tr>
<td>77 RR-110 Subparagraphs (d), (e), and (f) added (07-622)</td>
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<tr>
<td>77 RR-112 Cross-reference to &quot;UG-136&quot; revised to &quot;UG-140&quot; (07-622)</td>
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<td>77 RR-130 Subparagraph (c) deleted and subsequent subparagraph redesignated (07-622)</td>
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<tr>
<td>102 Article RS-2 Revised in its entirety (13-666)</td>
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<td>178 AD-501.2 Equations (16) and (20) revised (14-643)</td>
</tr>
</tbody>
</table>
| 181 AD-502 For $D_{12}$*, $D_{211}$*, and $D_{66}$*, "10[^{5*}]

(Note: Volume 63 of the Interpretations to Section X of the ASME Boiler and Pressure Vessel Code follows the last page of Section X.

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### LIST OF CHANGES IN RECORD NUMBER ORDER

<table>
<thead>
<tr>
<th>Record Number</th>
<th>Change</th>
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<tbody>
<tr>
<td>07-622</td>
<td>Added (d), (e), and (f) to RR-110. Replaced cross-reference to UG-136 with UG-140 in RR-112. Deleted RR-130(c) and subsequent subparagraph redesignated as (c).</td>
</tr>
<tr>
<td>13-666</td>
<td>ASME CA-1 standard is adopted to establish uniform requirements for conformity assessment. Added entry for ASME CA-1 to Table 1.1. Revised RS-200, RS-201, RS-202, and RS-203 by deleting contents and adding reference to ASME CA-1.</td>
</tr>
<tr>
<td>13-860</td>
<td>In the Foreword, the subtitle has been deleted and replaced with an ANSI disclaimer as a footnote.</td>
</tr>
<tr>
<td>14-643</td>
<td>Taper length corrected to 6 times laminate thickness in Figure RD-1174.2. Revised symbols in RD-1188.5. Revised numerical values in Nonmandatory Appendix AD.</td>
</tr>
</tbody>
</table>
There have been structural and stylistic changes to BPVC, starting with the 2011 Addenda, that should be noted to aid navigating the contents. The following is an overview of the changes:

Subparagraph Breakdowns/Nested Lists Hierarchy
- First-level breakdowns are designated as (a), (b), (c), etc., as in the past.
- Second-level breakdowns are designated as (1), (2), (3), etc., as in the past.
- Third-level breakdowns are now designated as (-a), (-b), (-c), etc.
- Fourth-level breakdowns are now designated as (-1), (-2), (-3), etc.
- Fifth-level breakdowns are now designated as (+a), (+b), (+c), etc.
- Sixth-level breakdowns are now designated as (+1), (+2), etc.

Footnotes
With the exception of those included in the front matter (roman-numbered pages), all footnotes are treated as endnotes. The endnotes are referenced in numeric order and appear at the end of each BPVC section/subsection.

Submittal of Technical Inquiries to the Boiler and Pressure Vessel Standards Committees
Submittal of Technical Inquiries to the Boiler and Pressure Vessel Standards Committees has been moved to the front matter. This information now appears in all Boiler Code Sections (except for Code Case books).

Cross-References
It is our intention to establish cross-reference link functionality in the current edition and moving forward. To facilitate this, cross-reference style has changed. Cross-references within a subsection or subarticle will not include the designator/identifier of that subsection/subarticle. Examples follow:
- **(Sub-)Paragraph Cross-References.** The cross-references to subparagraph breakdowns will follow the hierarchy of the designators under which the breakdown appears.
  - If subparagraph (-a) appears in X.1(c)(1) and is referenced in X.1(c)(1), it will be referenced as (-a).
  - If subparagraph (-a) appears in X.1(c)(1) but is referenced in X.1(c)(2), it will be referenced as (1)(-a).
  - If subparagraph (-a) appears in X.1(c)(1) but is referenced in X.1(e)(1), it will be referenced as (c)(1)(-a).
  - If subparagraph (-a) appears in X.1(c)(1) but is referenced in X.2(c)(2), it will be referenced as X.1(c)(1)(-a).
- **Equation Cross-References.** The cross-references to equations will follow the same logic. For example, if eq. (1) appears in X.1(a)(1) but is referenced in X.1(b), it will be referenced as eq. (a)(1)(1). If eq. (1) appears in X.1(a)(1) but is referenced in a different subsection/subarticle/paragraph, it will be referenced as eq. X.1(a)(1)(1).
ARTICLE RG-1
SCOPE AND JURISDICTION

RG-100 SCOPE

(a) Section X establishes the requirements for the fabrication of fiber-reinforced thermosetting plastic pressure vessels for general service, sets limitations on the permissible service conditions, and defines the types of vessels to which these rules are not applicable.

(b) To assure that vessels fabricated according to these rules will be capable of safely withstanding the operating conditions specified by the Design Specification, this Section:

(1) gives minimum requirements for the materials of fabrication;

(2) specifies test procedures for determining laminate mechanical properties;

(3) Defines three methods of design qualification:
   (-a) Class I Design — nondestructive qualification test
   (-b) Class II Design — mandatory design rules and acceptance testing by nondestructive evaluation (NDE) methods
   (-c) Class III Design — qualification of a vessel design through the destructive test of a prototype

(4) suggests nonmandatory design procedures for Class I vessels;

(5) provides mandatory design procedures and acceptance testing for Class II vessels;

(6) defines the general methods of fabrication which may be used;

(7) limits the types of end closures, connections, and attachments which may be employed and the means used to join them to the vessels;

(8) stipulates the procedures to be used in proving that prototype vessels will withstand specified operating and test conditions;

(9) establishes rules under which fabricating procedures used for fabricating Class I and Class III prototype and production vessels are qualified, and defines what deviations from such procedures necessitate requalification;

(10) sets forth requirements to assure that no essential variation in qualified fabrication procedures has occurred;

(11) establishes rules for acceptance testing, inspection, and reporting;

(12) gives requirements for stamping and marking.

(c) For vessels fabricated in accordance with these rules, the provisions of Section X shall apply over any other sections of the Code. When metallic components are part of fiber-reinforced plastic vessels, they shall meet the provisions of Section VIII, Division 1.

(d) The fabricator shall establish the effective Code edition, addenda and Code Cases for pressure vessels and replacement parts in accordance with Mandatory Appendix 9.

RG-110 APPLICATION LIMITATIONS

RG-111 DESIGN PRESSURE

The internal design pressure of vessels fabricated under this Section shall be limited as follows:

(a) Class I vessels shall not exceed 150 psi (1 MPa) for bag-molded, centrifugally cast, and contact-molded vessels; 1,500 psi (10 MPa) for filament-wound vessels and 3,000 psi (20 MPa) for filament-wound vessels with polar boss openings.

(b) Class II vessels shall not exceed the limits specified in RD-1120.

(c) Class III vessels shall not exceed 15,000 psi (103.4 MPa) for filament wound vessels with polar boss openings.

RG-112 DESIGN TEMPERATURE

The design temperature of vessels fabricated under this Section shall not exceed the lower of (a) or (b).

(a) 250°F (120°C) for Class I and Class II, and 185°F (85°C) for Class III.

(b) 35°F (19°C) below the maximum use temperature (see RM-121) of the resin, nor be less than −65°F (−54°C) (see RD-112).