

CODE CASES

2025

ASME Boiler and
Pressure Vessel Code
An International Code

**Boilers and
Pressure Vessels**

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AN INTERNATIONAL CODE

2025 ASME Boiler & Pressure Vessel Code

2025 Edition

July 1, 2025

CODE CASES

Boilers and Pressure Vessels



The American Society of
Mechanical Engineers

Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: July 1, 2025

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The endnotes and preamble in this document (if any) are part of this American National Standard.



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Library of Congress Catalog Card Number: 56-3934

Adopted by the Council of The American Society of Mechanical Engineers, 1914; latest edition 2025.

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

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FOREWORD*

(25)

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 In 2009, the Boiler and Pressure Vessel Committee was superseded by the following committees: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. The rules govern the construction** of boilers, pressure vessels, transport tanks, and nuclear components, and the inservice inspection of nuclear components and transport tanks. For nuclear items other than pressure-retaining components, the Committee also establishes rules of safety related to structural integrity. 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. The 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 and, for nuclear items other than pressure-retaining components, structural 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 components addressed by the Code. 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.

The 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

* 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.

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 proprietary 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 the Code. Requests for revisions, new rules, Code cases, or interpretations shall be addressed to the staff secretary in writing and shall give full particulars in order to receive consideration and action (see the Correspondence With the Committee page). Proposed revisions to the Code resulting from inquiries will be presented 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 submitted 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 Committee. ASME is to be notified should questions arise concerning improper use of the ASME Single Certification Mark.

When required by context in the Code, the singular shall be interpreted as the plural, and vice versa.

The words "shall," "should," and "may" are used in the Code as follows:

- *Shall* is used to denote a requirement.
- *Should* is used to denote a recommendation.
- *May* is used to denote permission, neither a requirement nor a recommendation.

CORRESPONDENCE WITH THE 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 Section of the ASME Boiler and Pressure Vessel Code (BPVC) should be sent to the staff secretary noted on the Section's committee web page, accessible at <https://go.asme.org/CSCcommittees>.

NOTE: See ASME BPVC Section II, Part D for guidelines on requesting approval of new materials. See Section II, Part C for guidelines on requesting approval of new welding and brazing materials ("consumables").

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 and Special Notices at <http://go.asme.org/BPVCerrata>. Errata and Special Notices become effective on the date posted. Users can register on the committee web page to receive email notifications of posted errata and Special Notices.

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, 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 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) The committee will consider proposed cases concerning the following topics only:
 - (1) equipment to be marked with the ASME Single Certification Mark, or
 - (2) equipment to be constructed as a repair/replacement activity under the requirements of Section XI
- (d) 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 Section and the paragraph, figure, or table number to which the proposed case applies
 - (4) the editions of the Code to which the proposed case applies
- (e) A case is effective for use when the public review process has been completed and it is approved by the cognizant supervisory board. Cases that have been approved will appear in the next edition or supplement of the Code Cases books, "Boilers and Pressure Vessels" or "Nuclear Components." Each Code Cases book is updated with seven Supplements.

Supplements will be sent or made available automatically to the purchasers of the Code Cases books until the next edition of the Code. Annulments of Code Cases become effective six months after the first announcement of the annulment in a Code Case Supplement or Edition of the appropriate Code Case book. The status of any case is available at <http://go.asme.org/BPVCCDatabase>. An index of the complete list of Boiler and Pressure Vessel Code Cases and Nuclear Code Cases is available at <http://go.asme.org/BPVCC>.

Interpretations

(a) Interpretations clarify existing Code requirements and are written as a question and reply. Interpretations do not introduce new requirements. If a revision to resolve conflicting or incorrect wording is required to support the interpretation, the committee will issue an intent interpretation in parallel with a revision to the Code.

(b) Upon request, the committee will render an interpretation of any requirement of the Code. An interpretation can be rendered only in response to a request submitted through the online Inquiry Submittal Form at <http://go.asme.org/InterpretationRequest>. Upon submitting the form, the inquirer will receive an automatic email confirming receipt.

(c) ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Code requirements. If, based on the information submitted, it is the opinion of the committee that the inquirer should seek assistance, the request will be returned with the recommendation that such assistance be obtained. Inquirers may track the status of their requests at <http://go.asme.org/Interpretations>.

(d) 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.

(e) Interpretations are published in the ASME Interpretations Database at <http://go.asme.org/Interpretations> as they are issued.

Committee Meetings

The ASME BPVC committees regularly hold meetings that are open to the public. Persons wishing to attend any meeting should contact the secretary of the applicable committee. Information on future committee meetings can be found at <http://go.asme.org/BCW>.

SUMMARY OF CHANGES

The 2025 Edition of the Code Cases includes Code Case actions published through Supplement 7 to the 2023 Edition.

Changes listed below are identified on the pages by a margin note, **(25)**, placed next to the affected area. Errata, if any, are identified by a margin note, **(E)**, placed next to the affected area.

<i>Page</i>	<i>Location</i>	<i>Change</i>
iv	List of Sections	Title of Section XI, Division 1 revised
v	Foreword	Third, fourth, seventh, tenth, and eleventh paragraphs editorially revised
xi	Notes to Numeric Index	Revised
xii	Numeric Index	Updated
xxiii	Subject Index	Updated
xxxvi	Index of Material Specifications Referred to in Cases	Updated
3	1750-32	Revised
75	2180-9	Revised
103	2223-3	Impending annulment
121	2254-1	Impending annulment
161	2327-4	Revised
225	2440-1	Revised
229	2446-1	Revised
285	2516	Impending annulment
389	2628	Impending annulment
497	2692-1	Revised
919	2868-1	Annulled
921	2869-1	Revised
947	2883	Impending annulment
995	2904	Impending annulment
1121	2959-1	Annulled
1195	2982-2	(1) In Table 7, under "Seamless Pipe," subcolumn heads corrected to "Yield Strength" and "Tensile Strength" by errata (2) In Table 7M, under "Seamless Pipe," subcolumn heads corrected to "Yield Strength" and "Tensile Strength" by errata
1277	3021	Annulled
1341	3044	Annulled
1361	3053	Impending annulment
1439	3070	Impending annulment
1457	3078-1	Revised
1467	3079	Impending annulment
1503	3094	Added
1505	3095	Added
1507	3096	Added
1509	3097	Added
1511	3098	Added
1513	3099	Added
1515	3100	Added
1517	3101	Added
1519	3102	Added

CROSS-REFERENCING IN THE ASME BPVC

Paragraphs within the ASME BPVC may include subparagraph breakdowns, i.e., nested lists. The following is a guide to the designation and cross-referencing of subparagraph breakdowns:

(a) Hierarchy of Subparagraph Breakdowns

- (1)* First-level breakdowns are designated as (a), (b), (c), etc.
- (2)* Second-level breakdowns are designated as (1), (2), (3), etc.
- (3)* Third-level breakdowns are designated as (-a), (-b), (-c), etc.
- (4)* Fourth-level breakdowns are designated as (-1), (-2), (-3), etc.
- (5)* Fifth-level breakdowns are designated as (+a), (+b), (+c), etc.
- (6)* Sixth-level breakdowns are designated as (+1), (+2), etc.

(b) Cross-References to Subparagraph Breakdowns. Cross-references within an alphanumerically designated paragraph (e.g., PG-1, UIG-56.1, NCD-3223) do not include the alphanumeric designator of that paragraph. The cross-references to subparagraph breakdowns follow the hierarchy of the designators under which the breakdown appears. The following examples show the format:

- (1)* If X.1(c)(1)(-a) is referenced in X.1(c)(1), it will be referenced as (-a).
- (2)* If X.1(c)(1)(-a) is referenced in X.1(c)(2), it will be referenced as (1)(-a).
- (3)* If X.1(c)(1)(-a) is referenced in X.1(e)(1), it will be referenced as (c)(1)(-a).
- (4)* If X.1(c)(1)(-a) is referenced in X.2(c)(2), it will be referenced as X.1(c)(1)(-a).

NOTES TO NUMERIC INDEX

(25)

- All Code Cases remain available for use until annulled by the ASME Boiler and Pressure Vessel Standards Committees. Code Cases will be reviewed routinely for possible incorporation into the body of the ASME Boiler and Pressure Vessel Code.
- Supplement 7 is the last supplement published for the 2023 edition. Supplement 8 is incorporated into the 2025 edition.
- Cases may be used beginning with the date of approval shown on the Case.
- Annulled Cases will remain in the Numeric Index and Subject Index until the next Edition, at which time they will be deleted.
- Newly revised cases supersede previous versions. Previous Code Case number will be added in the “Annulled Date/Supersedes” column next to the newly revised Code Case.
- The digit following a Case Number is used to indicate the number of times a Case has been revised.
- The Cases are arranged in numerical order, and each page of a Case is identified at the top with the appropriate Case Number.

Legend of Abbreviations

Supp. = Supplement

R = Reinstated

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2833	7-15-2015
2834	7-15-2015
2835	9-15-2015
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2874	11-30-2016
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2979	12-4-2019
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2983	12-2-2019
2984-1	2-8-2022
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CHARTS FOR VESSELS UNDER EXTERNAL PRESSURE

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Case 1325-18

Nickel-Iron-Chromium Alloys 800 and 800H (UNS N08800 and N08810) and Nickel-Iron-Chromium-Molybdenum-Copper Low-Carbon Alloy (UNS N08028)

Section I

Approval Date: June 23, 2005

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May Nickel-Iron-Chromium Alloys 800 and 800H (UNS N08800 and N08810) and nickel-iron-chromium-molybdenum-copper low-carbon alloy UNS N08028 conforming to the specifications listed in [Table 1](#) be used for water wetted service in Section I construction?

Reply: It is the opinion of the Committee that nickel-iron-chromium and nickel-iron-chromium-molybdenum-copper low-carbon alloy forms as shown in [Table 1](#) may be used for water wetted service in Section I construction provided the following requirements are met.

(a) The maximum allowable design stress shall not exceed that shown in Table 1B of Section II, Part D.

(b) Welded fabrication shall conform to the applicable requirements of Section I.

(1) The procedure and performance qualifications shall be conducted as prescribed in Section IX, except that the tensile strength of the reduced section specimen shall not be less than the minimum tensile strength of the materials specified in the Inquiry.

(2) Welding on N08800 and N08810 shall be done by any welding process or combination of processes capable of meeting the requirements. Welding on N08028 shall be by the gas tungsten arc process only.

(3) Welds that are exposed to corrosive action of the contents of the vessel should have a resistance to corrosion equal to that of the base metal. The use of filler metal that will deposit weld metal with practically the same composition as the material joined is recommended. When the manufacturer is of the opinion that a physically better joint can be made by departure from these limits, filler metal of a different composition may be used provided the strength of the weld metal at the operating temperature is not appreciably less than that of the high-alloy material to be welded, and user is satisfied that its

resistance to corrosion is satisfactory for the intended service.

(4) Where welding repair of a defect is required, it shall be followed by reexamination as required in PW-11. Where a defect is removed and welding repair is not necessary, care shall be taken to contour the surface so as to eliminate any sharp notches or corners. The contoured surface shall then be reinspected by the same means originally used for locating the defect to be sure it has been completely removed.

(5) When these materials are cold formed, the rules of Section I, para. PG-19 shall apply for alloys N08800 and N08810. Other than these requirements, any other heat treatment after forming or fabrication is neither required nor prohibited, but if heat treatment is applied to alloy N08028, it shall be performed at 1975°F–2085°F (1080°C–1140°C) followed by rapid cooling.

(c) This Case number shall be shown on the Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g. chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Product Specifications

Form	Specification
UNS N08800 and N08810	
Seamless condenser and heat exchanger tubes	SB-163
Rod and bars	SB-408
Seamless pipe and tube	SB-407
Plate, sheet, and strip	SB-409
Welded tubes	SB-515
UNS N08028	
Seamless tubes	SB-668
Plate, sheet, and strip	SB-709

Case 1750-32

Materials for Bodies, Bonnets, Yokes, Housings, and Holders of Pressure Relief Devices

(25)

Section I; Section VIII, Division 1; Section X; Section XII; Section XIII

Approval Date: February 3, 2025

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions and limitations may the following materials be utilized in the construction of the bodies, bonnets, and yokes of pressure relief valves, housing for breaking or buckling pin devices, and holders for rupture disks covered by the provisions of Section I; Section VIII, Division 1; Section X; Section XII; and Section XIII?

SA-351 Grade CK3MCuN
 SA-352 Grade LCC
 SA-675 Grades 50, 55, 60, 65, and 70
 SA-995 Grade CD4MCuN
 ASTM A108 Grades 1016, 1018, 1020, 1117, 1118, 1137, 1141, 1215, and 12L14
 ASTM A126
 ASTM A314 Type 303
 ASTM A494/A494M Grades CY-40, CZ-100, and M35-1
 ASTM A576 Grades 1040, 1042, 1045, and 1117
 ASTM A582 Types 303 and 416
 ASTM A744 Grade CK3MCuN
 ASTM B16
 ASTM B21 Alloys 464, 482, and 485
 ASTM B85 Alloy SC84B
 ASTM B176 Alloy C85800
 ASTM B211 Alloy 2024 Temper T351¹
 ASTM B283 Alloys C377, C464, and C485
 ASTM B365 Alloys R05200, R05400, R05255, and R05252
 ASTM B371 Alloys C69300, C69400, C69430, C69700, and C69710
 ASTM B392 Alloys R04200, R04210, R04251, and R04261
 ASTM B393 Alloys R04200, R04210, R04251, and R04261
 ASTM B453 Alloy C34500
 ASTM B584 Alloys C87400 and C84400

ASTM B708 Alloys R05200, R05400, R05255, and R05252

ASTM B927 Alloys C21000, C22000, C23000, C24000, C26000, C26800, C27000, and C27400

ASTM B981 Alloys C36300, C36500, C37000, C37100, and C37700

EN 1982 number CC499K, material conditions GC, GS, and GZ

EN 12164 number CW614N material conditions R360, R380, R400, and R430

EN 12164 number CW617N, material conditions R360 and R430

EN 12165:1998 number CW617N material condition H080

Reply: It is the opinion of the Committee that the materials described in the Inquiry may be used in the construction of the bodies, bonnets, and yokes of pressure relief valves, housings for breaking or buckling pin devices, and holders for rupture disks, covered by the provisions of Section I; Section VIII, Division 1; Section X; Section XII; and Section XIII, provided the following additional requirements and limitations are met:

(a) The pressure, temperature, and size limitations of [Table 1](#) shall apply.

(b) These materials shall not be welded, except as otherwise permitted by this Code Case.

(c) A representative finished model of each product size and design having a bonnet, body, or yoke of pressure relief valves, housings for breaking or buckling pin devices, and holders for rupture disks constructed of ASTM B16; ASTM B21 Alloys 464, 482, and 485; ASTM B176 Alloy C85800; ASTM B283 Alloys C377, C464, and C485; ASTM B371 Alloys C69300, C69400, C69430, C69700, and C69710; ASTM B453 Alloy C34500; EN 1982 number CC499K material conditions GC, GS, and GZ; EN 12164 number CW614N material conditions R360, R380, R400, and R430; EN 12164 number CW617N material conditions R360 and R430; EN 12165:1998 number CW617N material condition H080; ASTM B584 Alloy C84400; ASTM B927 Alloys C21000, C22000, C23000, C24000, C26000, C26800, C27000, and C27400; and ASTM B981 Alloys C36300, C36500, C37000, C37100, and C37700 shall be tested to determine the presence of residual stresses that

¹ Temper designation T351 designates rolled or cold finished rod or bar that has been solution heat treated, then given a minimum permanent set by stretching of 1% and maximum of 3%.

might result in failure of individual parts due to stress corrosion cracking. Tests shall be conducted in accordance with ASTM B154 or ASTM B858.

(d) Material conforming to ASTM B16; ASTM B371 Alloys C69300, C69400, C69430, C69700, and C69710; ASTM B453 Alloy C34500; ASTM B927 Alloys C21000, C22000, C23000, C24000, C26000, C26800, C27000, and C27400; and ASTM B981 Alloys C36300, C36500, C37000, C37100, and C37700 shall be tested to determine the presence of residual stresses that might result in failure of individual parts due to stress corrosion cracking. Tests shall be conducted in accordance with ASTM B154 or ASTM B858. The test frequency shall be as specified in SB-249.

(e) Material conforming to ASTM B16; ASTM B21 Alloys 464, 482, and 485; ASTM B927 Alloys C26000, C26800, C27000, and C27400 shall be used only in the soft and half-hard tempers.

(f) Material conforming to ASTM B584 Alloy C84400 or A108 Grades 1117, 1118, 1137, 1141, 1215, and 12L14 shall be limited in bodies, bonnets, and yokes of pressure relief valves, housings for breaking or buckling pin devices, and holders for rupture disks to use in zones subject only to secondary pressure.²

(g) Material conforming to ASTM A126 shall not be used for pressure relief valves, breaking or buckling pin devices, or rupture disks installed on vessels in lethal or flammable service.

(h) Material conforming to ASTM B85 Alloy SC84B shall be used only in air service.

(i) Material conforming to ASTM B211 Alloy 2024 Temper T351¹ shall not be used in Section I service.

(j) Material conforming to ASTM A108 Grades 1016, 1018, 1020, and 12L14 shall meet the fine grain limitations of ASTM A29. Each heat/lot of material shall be mechanically tested and the results reported per Supplementary Requirement S6 of ASTM A108. The results shall be reported to the purchaser (i.e., the pressure relief device manufacturer) in accordance with para. 10 of ASTM A108.

(k) Material conforming to SA-351 Grade CK3MCuN, SA-352 Grade LCC (SA-995 Grade CD4MCuN), and A744 Grade CK3MCuN may be repair welded in accordance with SA-351, SA-352, SA-995, A351, and A744 respectively.

(l) Material conforming to ASTM A494/A494M Grades CY-40, CZ-100, and M35-1, Class 1 may be repair welded in accordance with ASTM A494/A494M using welding procedures and welders qualified under Section IX.

(m) To prevent rotation after final setting, the adjustment screw may be tack welded to a valve body constructed of ASTM A576 Grade 1117 material, provided the weld is located in the secondary pressure zone of the valve body and is limited to the last thread of engagement

of the threaded interface between the adjustment screw and the valve body.

(n) Material conforming to EN 1982 number CC499K shall have the GC, GS, or GZ material condition denoting casting process. Inspection lot sampling for analysis and mechanical testing is mandatory. Certification is mandatory.

(o) Material conforming to EN 12164 number CW614N shall have the R360, R380, R400, and R430 material condition denoting mandatory tensile property requirements. Inspection lot sampling for analysis and mechanical testing is mandatory. Certification is mandatory.

(p) Material conforming to EN 12164 number CW617N shall have the R360 or R430 material condition denoting mandatory tensile property requirements. Inspection lot sampling for analysis and mechanical testing is mandatory. Certification is mandatory.

(q) Material conforming to EN 12165: 1998 number CW617N shall have the H080 material condition denoting mandatory hardness requirements. Inspection lot sampling for analysis and mechanical testing is mandatory. Certification is mandatory.

(r) The minimum 0.2% proof strength value of materials EN 12164 numbers CW614N and CW617N, condition R360 shall be 150 MPa.

(s) See Section II, Part B, Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 1982, EN 12164, and EN 12165: 1998, and their references.

(t) Material conforming to SA-675 Grades 50, 55, 60, 65, and 70

(1) may be used without conforming to the requirements of Supplementary Requirement S7.1 for nonwelded applications

(2) shall be supplied in one of the following requirements unless governed by UG-20(f)

(-a) if purchased to a coarse austenitic grain structure, a Charpy impact test shall be performed at -20°F and meet the requirements of Figure UG-84.1

(-b) if purchased to a fine austenitic grain structure, the material shall be normalized.

(u) All other restrictions and limitations placed on the use of these types of materials in Section I; Section VIII, Division 1; Section X; Section XII; or Section XIII shall be complied with.

² Secondary pressure is that existing in the body or outlet of the device during operation of the device.

**Table 1
Limitations**

Material	Limitations		
	Maximum Pressure Design Basis	Permissible Design Temperature	Maximum Size
ASTM B371: Alloys C69300, C69400, C69430, C69700, and C69710	[Note (1)]	406°F max.	Not over NPS 3
ASTM B584: Alloys C87400 and C84400:	No limit	406°F max.	Not over NPS 3
ASTM B16	No limit	406°F max.	Not over NPS 3
ASTM B21: Alloys 464, 482, and 485	No limit	406°F max.	Not over NPS 3
ASTM B176: Alloy C85800	No limit	406°F max.	Not over NPS 3
ASTM B211: Alloy 2024 Temper T351	No limit	406°F max.	Not over NPS 3
ASTM B283: Alloys C377, C464, and C485	No limit	406°F max.	Not over NPS 3
ASTM B453: Alloy C34500	No limit	406°F max.	Not over NPS 3
ASTM B85: Alloy SC84B	300 psi	150°F max.	No limit
ASTM A126	250 psi	-20°F to 450°F	No limit
ASTM A108: Grades 1117, 1118, 1137, 1141, and 1215	[Note (2)] and [Note (3)]	-20°F to 500°F	Not over NPS 2
ASTM A314: Type 303	[Note (4)]	-20°F to 500°F	Not over NPS 2
ASTM A576: Grade 1117	[Note (2)] and [Note (3)]	-20°F to 500°F	Not over NPS 2
ASTM A 582: Types 303 and 416	No limit	-20°F to 500°F	Not over NPS 2
ASTM A108: Grades 1016, 1018, and 1020	[Note (2)]	-20°F to 400°F	Not over NPS 2
ASTM A108: Grade 12L14	[Note (2)]	-20°F to 250°F	Not over NPS 2
ASTM B393: Alloys R04200, R04210, R04251, and R04261	No limit	400°F max.	No limit
ASTM B392: Alloys R04200, R04210, R04251, and R04261	No limit	400°F max.	No limit
ASTM B365: Alloys R05200, R05252, R05255, and R05400	No limit	400°F max.	No limit
ASTM B708: Alloys R05200, R05252, R05255, and R05400	No limit	400°F max.	No limit
ASTM B927: Alloys C21000, C22000, C23000, C24000, C26000, C26800, C27000, and C27400	[Note (5)]	406°F max.	Not over NPS 3
ASTM B981: Alloys C36300, C36500, C37000, C37100, and C37700	[Note (6)]	406°F max.	Not over NPS 3
SA-351: Grade CK3MCuN	[Note (7)]	700°F max.	No limit
SA-352: Grade LCC	[Note (7)]	-55°F to 650°F	No limit
SA-675: Grades 50, 55, 60, 65, and 70	No limit	-20°F to 500°F	Not over NPS 2
SA-995: Grade CD4MCuN	[Note (7)]	500°F max.	No limit
ASTM A494/A494M:			
Grade CZ-100	[Note (8)]	750°F max.	No limit
Grade CY-40	[Note (9)]	900°F max.	No limit
Grade M35-1	[Note (10)]	900°F max.	No limit
ASTM A576: Grades 1040, 1042, and 1045	[Note (2)]	-20°F to 650°F	No limit
ASTM A744 Grade CK3MCuN	[Note (11)]	700°F max.	No limit
EN 1982 number CC499K: material conditions GC, GS, and GZ	No limit	406°F max.	Not over NPS 3
EN 12164: number CW614N material conditions R360, R380, R400, and R430	[Note (12)]	406°F max.	Not over NPS 3
EN 12164: number CW617N, material conditions R360 and R430	No limit	406°F max.	Not over NPS 3
EN 12165:1998 number CW617N material condition H080	No limit	406°F max.	Not over NPS 3

Table 1
Limitations (Cont'd)

NOTES:

- (1) For Alloys C69300, C69400, and C69430, use the allowable stress values provided for ASTM B371, C69300 specified in ASME B31.3 Appendix A, Table A-1 up to and including 300°F. Above 300°F, use allowable stress values provided for SB-315, C66500, O61 specified in ASME Section II, Part D, Table 1B. For Alloys C69700 and C69710, use allowable stress values provided for SB-98, C65500, H02 up to and including 350°F, and for temperatures above 350°F, use allowable stress values provided for SB-315, C65500 O61 specified in Section II, Part D, Table 1B.
- (2) ASME B16.5 — Class 600 Material Group 1.1 Ratings.
- (3) Use of grades to which Bi, Se, or Te have been added is prohibited.
- (4) ASME B16.5 — Class 600 Material Group 2.1 Ratings.
- (5) Use allowable stress values for SB-135, C23000, O60 specified in Section II, Part D, Table 1B.
- (6) Use allowable stress values for SB-171, C36500, O25 for thickness ≤ 2 in. in Section II, Part D, Table 1B.
- (7) ASME Section II, Part D, Tables 1A and 1B allowable stresses.
- (8) ASME B16.5 — Class 600 Material Group 3.2 Ratings.
- (9) ASME B16.5 — Class 600 Material Group 3.4 Ratings.
- (10) ASME B16.5 — Class 2500 Material Group 3.4 Ratings.
- (11) ASME Section II, Part D, Table 1A (Ref. SA-351, Grade CK3MCuN allowable stresses).
- (12) Use allowable stress values for SB-171, C36500 O25 for thickness ≤ 2 in. and thickness $2 \text{ in.} < t \leq 3.5 \text{ in.}$ in Section II, Part D, Table 1B. The tempers in EN 12164, CW614N material without a specified yield strength have to meet the specified yield strength for SB-171, C36500 O25.

Case 1827-3

Nickel-Chromium-Iron (Alloy N06600) for Water-Wetted Service

Section I

Approval Date: December 30, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May nickel-chromium-iron (Alloy UNS N06600) seamless condenser and heat exchanger tubes, seamless pipe and tubes, plate, sheet and strip, rod and bar, conforming to the Specifications SB-163, SB-166, SB-167, and SB-168, be used for water-wetted service in Section I construction?

Reply: It is the opinion of the Committee that nickel-chromium-iron (Alloy UNS N06600) conforming to the Specifications SB-163, SB-166, SB-167, and SB-168 may be used for water-wetted service in Code construction under Section I provided:

(a) They meet the chemical analysis and the minimum tensile requirements of the ASME specifications for the respective forms.

(b) The maximum allowable stress values for the material shall be those given in Table 1B of Section II, Part D.

(c) Welded fabrication shall conform to the applicable requirements of Section I.

(1) The procedure and performance qualifications shall be conducted as prescribed in Section IX.

(2) Welding shall be done by any welding process or combination of processes capable of meeting the requirements.

(3) The use of filler metal that will deposit weld metal with nominally matching composition as the material joined is recommended. When the Manufacturer is of

the opinion that a physically better joint can be made by departure from these limits, filler metal of a different composition may be used provided the strength of the weld metal at the operating temperature is not appreciably less than that of the high alloy material to be welded, and the user is satisfied that its resistance to corrosion is satisfactory for the intended service.

(4) Where welding repair of a defect is required, this shall be followed by reexamination as required in PW-11. Where a defect is removed and welding repair is not necessary, care shall be taken to contour the surface so as to eliminate any sharp notches or corners. The contoured surface shall then be reinspected by the same means originally used for locating the defect to be sure it has been completely removed.

(d) Heat treatment after forming or fabrication is neither required nor prohibited.

(e) This Case number will be shown on the Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

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Case 1849-1

Gray Cast Iron Castings

Section I

Approval Date: August 4, 2004

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May gray iron castings conforming to SA-278 Grades 20, 25, 30, and 35 be used in construction of economizer tubing under Section I rules?

Reply: It is the opinion of the Committee that gray iron castings conforming to SA-278 Grades 20, 25, 30, and 35 as shown in Table 1 may be used for construction of economizer tubing under Section I rules under the following conditions, provided all other requirements of Section I are satisfied.

(a) Service Restrictions

(1) Cast iron economizer tubing shall not be used where subject to direct radiation from the furnace.

(2) The design pressure for the economizer tubing shall not exceed 250 psi (1700 kPa) at temperatures not greater than 450°F (232°C).

(3) Cast iron flanges and flanged fittings conforming to ANSI B 16.1-75, Cast Iron Pipe Flanges and Flanged Fittings, Class 125 and 250, may be used for pressures not exceeding the American National Standard ratings for temperatures not exceeding 450°F (232°C).

(4) Material shall be tested in accordance with the requirements of Section II.

(5) All castings shall be finished free from surface defects, porosity, blow holes, and warping.

(6) Mating surfaces shall be machined.

(7) All internal pressure surfaces shall be circular in form.

(8) When no rules are given and it is impractical to calculate the strength of the economizer tubing with a reasonable degree of accuracy, the design pressure shall be determined in accordance with A-22 of Section I. A factor of 10 instead of 6.67 shall be used in the formula A-22.6.3.2.2. Where previous tests were conducted by the manufacturer in the presence of the authorized inspector, he may produce certified documentation of such tests.

(9) Economizers constructed of cast iron tubing shall be hydrostatically tested by the method described in PG-99 except that the test pressure shall be two times the maximum allowable working pressure.

(10) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for SA-278 Cast Iron

Spec No.	Class	Tensile Strength, min., ksi (MPa)	Allowable Stress, ksi (MPa), for Metal Temp. Not Exceeding 450°F (232°C)
SA-278	20	20.0 (140)	2.0 (13.8)
SA-278	25	25.0 (170)	2.5 (17.2)
SA-278	30	30.0 (205)	3.0 (20.7)
SA-278	35	35.0 (240)	3.5 (24.1)

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Case 1855-2

Section VIII, Division 1, Unfired Steam Boiler in Section I System

Section I

Approval Date: December 18, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Code rules permit unfired steam boilers as defined in the Preamble of Section I to be constructed under the provisions of Section I or Section VIII, Division 1. If it is desired to construct an unfired steam boiler under the provisions of Section VIII, Division 1, under what conditions may it be installed in a Section I system?

Reply: It is the opinion of the Committee that an unfired steam boiler constructed in accordance with the rules of Section VIII, Division 1 [see UW-2(c)], may be installed in a Section I system when the requirements of PG-58, PG-59, PG-60, PG-61, and PG-67 through PG-73 of Section I, applicable to piping and protective devices, are satisfied by an appropriate Section I certificate holder, and when the following additional requirements are satisfied.

(a) When any steam drum is not an integral part of the unfired boiler it shall be constructed in accordance with Section VIII, Division 1, including UW-2(c) or in accordance with Section I.

(b) *Materials*

(1) For those vessels or chambers constructed to Section VIII, Division 1 rules, the materials shall be limited to those permitted by Section VIII, Division 1;¹

(2) For those portions constructed to Section I rules, the materials shall be limited to those permitted by Section I.

(c) Welds in unfired steam boilers shall be postweld heat treated to the minimum holding time and temperature requirements of Section VIII, Division 1 unless the welds satisfy the exemptions in both Section I and Section VIII, Division 1.

(d) *Stamping and Data Reports*

(1) Those vessels or chambers constructed to Section VIII, Division 1 rules shall be stamped with the ASME Code "U" Symbol and additional marking required by UG-116, and be documented with the ASME U-1 or U-1A Data Report. A nameplate per UG-119 shall be furnished and shall be marked "Case___."

(2) All portions constructed to the rules of Section I shall be stamped with the applicable Section I Symbol and be documented with the applicable Section I data report forms. This Case number shall be shown on the Section I master stamping.

(3) This Case number shall be shown on the Section VIII Manufacturer's Data Report for the unfired steam boiler and the Section I Master Data Report.

¹ Except that any nonintegral steam drum, in water or steam service, shall be constructed of materials permitted by Section I, PG-9.1.

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Case 1876-6

Design of Safety Valve Connections

Section I

Approval Date: March 4, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For Section I construction, what design criteria may be used for boiler proper safety valve inlet connections?

Reply: It is the opinion of the Committee that, for Section I construction, the following design criteria may be used for safety valve inlet connections to the boiler proper:

(a) For the condition with the safety valve closed, the wall thickness of the connection shall be no less than required by the rules of PG-27 for the internal pressure using the maximum allowable stress from Table 1A of Section II, Part D.

(b) For the condition of safety valve operation (blowing steam), the combined pressure stress and bending stress from internal pressure plus valve reaction forces may exceed the allowable stresses in Table 1A of Section II, Part D, but shall not exceed the values shown in [Tables 1](#) and [1M](#).

(c) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Combined Stress in Safety Valve Inlet Connection When Valve Is Blowing

Temperature, °F	Carbon Steel, ksi [Note (1)] and [Note (2)]	1¼Cr-½Mo-Si, ksi [Note (3)]	2¼Cr-1Mo, ksi [Note (4)]	9Cr-1Mo-V, ksi [Note (5)]
-20 to 400	23.0	22.8	24.2	49.2
500	22.0	22.0	24.2	49.2
600	20.7	21.2	24.2	49.1
650	20.0	20.8	24.2	48.6
700	19.4	20.3	24.2	47.9
750	18.7	20.0	24.1	46.8
800	15.1	19.4	23.9	44.9
850	11.8	18.9	23.6	39.3
900	...	18.4	23.0	34.0
950	...	17.6	22.3	28.9
1,000	...	16.9	17.7	24.2
1,050	...	12.1	13.1	19.8
1,100	...	...	9.7	15.8
1,150	...	...	...	12.2
1,175	...	...	...	10.6
1,200	...	...	...	9.2

GENERAL NOTES:

- (a) The stress values in this table may be interpolated to determine values for intermediate temperatures.
- (b) The stress values in this table do not exceed either 90% of the yield strength at temperature or 67% of the average stress to produce rupture in 1,000 hr. Values based on time-dependent properties utilize 67% of the average stress to produce rupture in 1,000 hr.

NOTES:

- (1) Upon prolonged exposure to temperatures above about 800°F, the carbide phase of carbon steel may be converted to graphite.
- (2) Material shall conform to one of the following Specifications and Grades:

Specification No.	Grade or Class
SA-105	...
SA-106	B, C
SA-181	60, 70
SA-210	C, A1
SA-216	WCA, WCB, WCC
SA-266	1, 2, 3, 4

Allowable stress values above 750°F are based on time-dependent properties.

- (3) Material shall conform to one of the following Specifications and Grades:

SA-182	F11, Class 2
SA-213	T11
SA-217	WC6
SA-335	P11

Allowable stress values above 1,000°F are based on time-dependent properties.

- (4) Material shall conform to one of the following Specifications and Grades:

SA-182	F22, Class 3
SA-213	T22
SA-217	WC9
SA-335	P22
SA-336	F22, Class 1; F22, Class 3

Allowable stress values above 950°F are based on time-dependent properties.

Table 1
Maximum Allowable Combined Stress in Safety Valve Inlet Connection When Valve Is Blowing (Cont'd)

NOTES: (Cont'd)

(5) Material shall conform to one of the following Specifications and Grades:

SA-182	F91
SA-213	T91
SA-335	P91
SA-336	F91
A1091/A1091M-16	C91

Allowable stress values above 800°F are based on time-dependent properties.

Table 1M
Maximum Allowable Combined Stress in Safety Valve Inlet Connection When Valve Is Blowing

Temperature, °C	Carbon Steel, MPa [Note (1)] and [Note (2)]	1 ¹ / ₄ Cr- ¹ / ₂ Mo-Si, MPa [Note (3)]	2 ¹ / ₄ Cr-1Mo, MPa [Note (4)]	9Cr-1Mo-V, MPa [Note (5)]
-30 to 204	159	157	167	339
250	153	152	167	339
300	145	148	167	339
325	141	145	167	338
350	137	142	167	334
375	133	140	167	329
400	129	138	167	322
425	106	134	166	312
450	85.2	131	163	277
454	82.2	130	162	271
475	...	128	160	244
500	...	123	156	212
525	...	119	141	182
550	...	102	107	153
566	...	83.2	90.2	137
575	...	...	81.8	127
593	...	...	67.3	109
600	...	...	...	103
625	...	...	...	80.9
649	...	...	...	63.1

GENERAL NOTES:

- (a) The stress values in this table may be interpolated to determine values for intermediate temperatures.
- (b) The stress values in this table do not exceed either 90% of the yield strength at temperature or 67% of the average stress to produce rupture in 1 000 hr. Values based on time-dependent properties utilize 67% of the average stress to produce rupture in 1 000 hr.

NOTES:

- (1) Upon prolonged exposure to temperatures above about 425°C, the carbide phase of carbon steel may be converted to graphite.
- (2) Material shall conform to one of the following Specifications and Grades:

Specification No.	Grade or Class
SA-105	...
SA-106	B, C
SA-181	60, 70
SA-210	C, A1
SA-216	WCA, WCB, WCC
SA-266	1, 2, 3, 4

Allowable stress values above 400°C are based on time-dependent properties.

- (3) Material shall conform to one of the following Specifications and Grades:

SA-182	F11, Class 2
SA-213	T11
SA-217	WC6
SA-335	P11

Allowable stress values above 525°C are based on time-dependent properties.

Table 1M
Maximum Allowable Combined Stress in Safety Valve Inlet Connection When Valve Is Blowing (Cont'd)

NOTES: (Cont'd)

(4) Material shall conform to one of the following Specifications and Grades:

SA-182	F22, Class 3
SA-213	T22
SA-217	WC9
SA-335	P22
SA-336	F22, Class 1; F22, Class 3

Allowable stress values above 500°C are based on time-dependent properties.

(5) Material shall conform to one of the following Specifications and Grades:

SA-182	F91
SA-213	T91
SA-335	P91
SA-336	F91
A1091/A1091M-16	C91

Allowable stress values above 425°C are based on time-dependent properties.

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Case 1924-2

Nickel-Molybdenum-Chromium Alloy (UNS N10276)

Section I

Approval Date: December 30, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May nickel-molybdenum-chromium alloy (UNS N10276) fittings, rod, plate, sheet and strip, welded pipe, seamless pipe and tube, and welded tube conforming to SB-366, SB-574, SB-575, SB-619, SB-622, and SB-626 be used for water-wetted service Section I construction?

Reply: It is the opinion of the Committee that nickel-molybdenum-chromium alloy (UNS N10276) may be used for water-wetted service in Section I construction, provided the following additional requirements are met:

(a) The maximum allowable stress values for the material shall be those listed in Section II, Part D, Table 1B for SB-366, SB-574, SB-575, SB-619, SB-622, and SB-626.

(b) Welded fabrication shall conform to the applicable requirements of Section I.

(1) Welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(2) Welding shall be done by any welding process capable of meeting the requirements.

(3) Welding electrodes and filler metal shall conform to the requirements of PW-5.4.

(4) Where welding repair of a defect is required, it shall be followed by reexamination as required in PW-11. Where a defect is removed and welding repair is not necessary, care shall be taken to contour the surface so as to eliminate any sharp notches or corners. The contoured surface shall then be reinspected by the same means originally used for locating the defect to be sure it has been completely removed.

(c) Heat treatment after forming or fabrication is neither required nor prohibited.

(d) This Case number shall be identified in the Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environment. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environment, careful attention must be paid to continuous control of water chemistry.

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Case 1932-5

SA-736/SA-736M Plates and ASTM A859/A859M-95 Forgings

Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3

Approval Date: August 4, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may low-carbon, age-hardening nickel-copper-chromium-molybdenum-columbium alloy steel plates and forgings conforming to SA-736/SA-736M, Grade A, and ASTM specification A859/A859M-95, be used in welded construction under the rules of Section VIII, Divisions 1, 2, and 3?

Reply: It is the opinion of the Committee that the materials described in the Inquiry may be used under the rules of Section VIII, Divisions 1, 2, and 3, subject to the following additional requirements:

(a) The following allowable stress values, the allowable stress intensity values, and yield strength values shall apply:

(1) *Division 1.* The maximum allowable stress values shall be those shown in [Table 1](#).

(2) *Division 2.* The design stress intensity values, S_m , shall be those shown in [Table 2](#). The yield strength values, S_y , for Division 2 shall be those shown in [Table 3](#).

(3) *Division 3.* The yield strength values, S_y , for Division 3 shall be those shown in [Table 3](#) of this Code Case.

(b) For external pressure design, the following requirements shall apply:

(1) *Divisions 1 and 2.* Use Fig. CS-2 of Section II, Part D.

(2) *Division 3.* Use KD-222 of Section VIII, Division 3.

(c) Separate welding procedure and performance qualifications shall be conducted for these materials in accordance with Section IX.

(d) *Preheat.* Preheat is not required when the base metal temperature is 50°F or warmer, for nominal thicknesses up to 1½ in. inclusive. A preheat of 200°F is required for nominal thicknesses greater than 1½ in.

(e) *Postweld Heat Treatment.* Postweld heat treatment is prohibited.

(f) *Impact Test Requirement.* The following requirements shall apply:

(1) *Divisions 1 and 2.* For material with thicknesses greater than 1½ in. up to and including 4 in., the lateral expansion at the lowest permissible temperature (MDMT) specified shall be 25 mils. minimum.

(2) *Division 3.* Transverse Charpy V-notch impact test specimens shall be used for Division 3 construction. The test specimens, the testing requirements, and the energy values shall meet the requirements of Article KM-2 in Part KM.

(g) The following requirements shall apply:

(1) *Division 1 Construction:* Part UCS.

(2) *Division 2 Construction:* Article M-2.

(3) *Division 3 Construction:* KM-101, Articles KM-2 and KE-2.

(h) For Division 3 construction, the materials certification shall be in accordance with KM-101 of Section VIII, Division 3.

(i) This Case number shall be shown on the Manufacturer's Data Report Form.

Table 1
Maximum Allowable Stress Values, Division 1, ksi

Specification, Grade, Class Thickness	For Metal Temperatures Not Exceeding 650°F [Note (1)]
A736, Grade A	
Class 1	
$t \leq \frac{3}{4}$ in.	25.7
Class 2	
$t \leq 2$ in.	20.6
2 in. $< t \leq 4$ in.	18.6
Class 3	
$t \leq 2$ in.	24.3
2 in. $< t \leq 4$ in.	21.4
A859	
Class 1	
$t \leq 4$ in.	18.6
Class 2	
$t \leq 4$ in.	21.4

NOTE: (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.

Table 2
Design Stress Intensity Values, S_m , Division 2, ksi

Specification, Grade, Class Thickness	For Metal Temperatures Not Exceeding 650°F
A736, Grade A	
Class 1	
$t \leq \frac{3}{4}$ in.	30.0
Class 2	
$t \leq 2$ in.	24.0
2 in. $< t \leq 4$ in.	21.7
Class 3	
$t \leq 2$ in.	28.3
2 in. $< t \leq 4$ in.	25.0
A859	
Class 1	
$t \leq 4$ in.	21.7
Class 2	
$t \leq 4$ in.	25.0

Table 3
Values of Yield Strength, S_y

Specification, Grade, Class Thickness, in.	Yield Strength, ksi, for Metal Temperature Not Exceeding, °F						
	100	200	300	400	500	600	650
A736, Grade A							
Class 1							
$t \leq 0.75$	80.0	75.3	72.6	69.4	67.6	65.5	64.2
Class 2							
$t \leq 1.00$	65.0	61.1	58.6	56.8	54.9	53.2	52.1
$1 < t \leq 2$	60.0	56.5	54.1	52.4	50.7	49.1	48.1
$2 < t \leq 4$	55.0	51.8	49.6	48.1	46.5	45.0	44.1
Class 3							
$t \leq 2$	75.0	70.6	67.6	65.6	63.4	61.4	60.2
$2 < t \leq 4$	65.0	61.1	58.6	56.8	54.9	53.2	52.1
A859							
Class 1							
$t \leq 4$ in.	55.0	51.8	49.6	48.1	46.5	45.0	44.1
Class 2							
$t \leq 4$ in.	65.0	61.1	58.6	56.8	54.9	53.2	52.1

Case 1934

Alternative Rules for Heat Treatment of Boiler External Piping

Section I

Approval Date: May 25, 1983

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May a Certificate Holder who assembles boiler external piping (PG-58.3) apply Section I preheat and PWHT requirements to boiler external piping in lieu of ANSI/ASME B31.1 requirements?

Reply: It is the opinion of the Committee that any holder of the ASME "S," "A," or "PP" symbol stamp and Certificate of Authorization may apply the preheat and PWHT requirements of Section I to boiler external piping in lieu of the corresponding requirements of B31.1.

This Case number shall be identified in the Manufacturer's Data Report Form.

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Case 1935-4

Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625)

Section I

Approval Date: September 23, 2007

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed (Grade 2) nickel-chromium-molybdenum-columbium alloy (UNS N06625) conforming to the specifications listed in [Table 1](#) be used for Section I welded construction in water wetted service?

Reply: It is the opinion of the Committee that solution annealed (Grade 2) nickel-chromium-molybdenum-columbium alloy (UNS N06625) as described in the Inquiry may be used¹ in Section I construction in water wetted service, provided the following additional requirements are met.

(a) The maximum allowable stress values shall be those listed in Section II, Part D, Table 1B. The maximum metal temperature shall not exceed 1000°F (538°C).

(b) Welded fabrication shall conform to the applicable requirements of Section I.

(1) The procedure and performance qualifications shall be conducted as prescribed in Section IX. The material is P-No. 43.

(2) Welding shall be done by any welding process or combination of processes capable of meeting the requirements.

(c) This Case number shall be identified in the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Material Specifications

Plate, sheet, and strip	SB-443
Seamless pipe and tube	SB-444
Rod and bar	SB-446

¹ Alloy N06625 is subject to severe loss of impact strength at room temperature after exposure in the range of 1000°F to 1100°F (540°C to 595°C).

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Case 1936-3

Nickel-Iron-Chromium-Molybdenum-Copper Alloy (UNS N08825) for Water Wetted Service

Section I

Approval Date: February 20, 2002

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May nickel-iron-chromium-molybdenum-copper alloy (UNS N08825) conforming to ASME specifications SB-423, SB-424, SB-425, and SB-704 be used for water wetted service in Section I construction?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used for water wetted service in Section I construction at a design temperature of 1000°F or less, provided the following additional requirements are met:

(a) The maximum allowable stress values for welded construction shall be those listed in Section II, Part D, Table 1B for SB-423, SB-424, and SB-425.

(b) For SB-704, the maximum allowable stresses shall be those given in Section II, Part D, Table 1B for Section VIII-1 use. Or, provided the following additional requirements are met, the stress values given in Section II, Part D, Table 1B for SB-423 may be used:

(1) The tubing shall be used for boiler, waterwall, superheater, and economizer tubes that are enclosed within the setting.

(2) The maximum outside diameter shall be 3½ in.

(3) The weld seam of each tube shall be subjected to an angle beam ultrasonic inspection per SB-751.

(4) A complete volumetric inspection of the entire length of each tube shall be performed in accordance with SB-751.

(5) Material test reports shall be supplied.

(c) Welded fabrication shall conform to the applicable requirements of Section I.

(1) The procedure and performance qualifications shall be conducted as prescribed in Section IX.

(2) Welding shall be done by any welding process or combination of processes capable of meeting the requirements.

(d) For external pressure design (see Section II, Part D), use Fig. NFN-7 up to and including 700°F. For temperatures above 700°F use Fig. NFN-8.

(e) This Case number shall be identified in the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

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Case 1949-4

Forgings of Nickel-Iron-Chromium Alloys N08800 and N08810

Section I

Approval Date: February 20, 2004

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May forgings of nickel-iron-chromium alloys N08800 and N08810 that conform to SB-564 be used for water wetted service in Code construction under Section I?

Reply: It is the opinion of the Committee that nickel-iron-chromium alloys N08800 and N08810 as described in the Inquiry may be used in Section I construction, provided the following additional requirements are met.

(a) The maximum allowable stress values shall be those listed in Table 1B of Section II, Part D.

(b) Welded fabrication shall conform to the applicable requirements of Section I.

(1) The procedure and performance qualification shall be conducted as prescribed in Section IX.

(2) Welding shall be done by any welding process or combination of processes capable of meeting the requirements.

(c) This Case number shall be shown on the Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

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Case 1968-1

Use of Acoustic Emission Examination in Lieu of Radiography

Section VIII, Division 1

Approval Date: December 2, 1990

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions and limitations may an acoustic emission (AE) examination conducted during the hydrostatic test be used in lieu of radiography (RT), when radiography in accordance with UW-51 is required by UW-11 of Section VIII, Division 1, for the circumferential closure weld in pressure vessels?

Reply: It is the opinion of the Committee that the circumferential closure weld in pressure vessels may be examined using the acoustic emission (AE) method in lieu of radiography (RT) provided that all of the following requirements are met.

(a) The materials of construction shall be P-No. 1 Group 1 or Group 2 and the weld thickness shall not exceed $2\frac{1}{2}$ in.

(b) The vessel shall not exceed 2 ft inside diameter, 2 ft inside length, or 7 ft³ capacity.

(c) The acoustic emission examination shall be performed in accordance with a written procedure that is certified by the manufacturer to be in accordance with Section V, Article 12, Acoustic Emission Examination of Metallic Vessels During Pressure Testing. The written procedure shall be demonstrated to the satisfaction of the Inspector.

(d) The manufacturer shall certify that personnel performing and evaluating AE examinations have been qualified and certified in accordance with their employer's written practice. SNT-TC-1A-1984 shall be used as a guideline for employers to establish a written practice for qualifying and certifying personnel. The qualification records of certified personnel shall be maintained by their employer.

(e) The AE examination shall be conducted throughout the hydrostatic test that is required by UG-99. Two pressurization cycles from atmospheric pressure to the test pressure required by UG-99 shall be used.

(f) Evaluation and acceptance criteria shall be as follows.

(1) During the first pressurization cycle, any rapid increase in AE events or any rapid increase in AE count rate shall require a pressure hold. If either of these conditions continues during the pressure hold, the pressure shall be immediately reduced to atmospheric pressure and the cause determined.

(2) During the second pressurization cycle, the requirements of (1) above shall apply and, in addition, the following AE indications shall be unacceptable:

(-a) any AE event during any pressure hold;

(-b) any single AE event that produces more than 500 counts, or that produces a signal attribute equivalent to 500 counts;

(-c) six or more AE events detected by any single sensor;

(-d) three or more AE events from any circular area whose diameter is equal to the weld thickness or 1 in., whichever is greater;

(-e) two or more AE events from any circular area (having a diameter equal to the weld thickness or 1 in., whichever is greater) that emitted multiple AE events during the first pressurization.

(g) Welds that produce questionable acoustic emission response signals (i.e., AE signals that cannot be interpreted by the AE examiner) shall be evaluated by radiography in accordance with UW-51. If the construction of the pressure vessel does not permit interpretable radiographs to be taken, ultrasonic examination may be substituted for radiography in accordance with UW-11(a)(7). Final acceptance (or rejection) of such welds shall be based on the radiographic or ultrasonic results, as applicable.

(h) The AE sensors shall be positioned so that the entire pressure vessel is monitored by the AE system and all AE response signals shall be recorded and used in the evaluation. The same AE acceptance standards shall be applied to the rest of the vessel that are applied to the circumferential closure weld.

(i) The AE test results and records shall be retained in accordance with the Section VIII requirements for radiographic film.

(j) This Case number shall be shown on the Data Report Form.

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Case 1993-7

Precipitation-Hardening Nickel Alloy (UNS N07718) Used as Bolting Material

Section I

Approval Date: October 26, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May precipitation-hardened nickel alloy rod, bar, forgings, and forging stock (UNS N07718) conforming to SB-637 be used as a bolting material for Section I construction?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used as a bolting material in Section I construction at a design temperature of 1,150°F (621°C) or less, provided the following additional requirements are met.

(a) The maximum allowable stress values shall be those listed in [Table 1](#) and [Table 1M](#).

(b) Except for nonstructural tack welds used as a locking device, no welding is permitted.

(c) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in the sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Maximum Allowable Stresses, ksi

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi
100	37.0
200	37.0
300	37.0
400	37.0
500	37.0
600	37.0
700	37.0
750	37.0
800	37.0
850	37.0
900	37.0
950	37.0
1,000	37.0
1,050	37.0
1,100	37.0
1,150	37.0

Table 1M
Maximum Allowable Stresses, MPa

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, Max., MPa
45	255
65	255
100	255
125	255
150	255
175	255
200	255
225	255
250	255
275	255
300	255
325	255
350	255
375	255
400	255
425	255
450	255
475	255
500	255
525	255
550	255
575	255
600	255
625 [Note (1)]	255

NOTE: (1) The value provided at 625°C is for interpolation use only. The maximum use temperature is 621°C.

Case 2016-1

Alternative Requirements for Seal Welding of Threaded Connections, UF-32(b)

Section VIII, Division 1

Approval Date: August 12, 1996

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For Section VIII, Division 1 construction, what alternative requirements may be used to qualify welding procedure and welder performance for seal welding of threaded connections in seamless forged pressure vessels of SA-372 Grades A, B, C, D, E, F, G, H, and J material in lieu of making a groove weld specimen as required for seal welding in Section VIII, Division 1, para. UF-32(a) for material with a permitted carbon content of 0.35% or less and in Section VIII, Division 1, para. UF-32(b) for material with a permitted carbon content exceeding 0.35%?

Reply: It is the opinion of the Committee that for Section VIII, Division 1 construction, the following requirements may be used to qualify welding procedure and welder performance for seal welding of threaded connections in seamless forged pressure vessels of SA-372 Grades A, B, C, D, E, F, G, H, and J material in lieu of making a groove weld specimen as required for seal welding in Section VIII, Division 1, para. UF-32(a) for material with a permitted carbon content of 0.35% or less and in Section VIII, Division 1, para. UF-32(b) for material with a permitted carbon content exceeding 0.35%.

(a) The suitability of the welding procedure, including electrode, and the welder performance shall be established by making a seal weld in the welding position to be used for the actual work and in a full-size prototype of the vessel neck, including at least some portion of the integrally forged head, conforming to the requirements of Section VIII, Division 1, para. UF-43 and the same geometry, thickness, vessel material type, threaded-plug material type, and heat treatment as that for the production vessel it represents. Separate welding procedure qualifications and performance qualifications shall be conducted for each grade.

(b) The seal weld in the prototype at the threaded connection of the neck and plug shall be cross-sectioned to provide four macro-test specimens taken 90 deg. apart.

(c) One face of each cross section shall be smoothed and etched with a suitable etchant (see Section VIII, Division 1, para. QW-470) to give a clear definition of the weld metal and heat affected zone. Visual examination of the cross sections of the weld metal and heat affected zone shall show complete fusion and freedom from cracks.

(d) All production welding shall be done in accordance with the procedure qualification of (a) above, including the preheat and the electrode of the same classification as that specified in the procedure, and with welders qualified using that procedure

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2038-5

25Cr-22Ni-2Mo-N, UNS S31050, Austenitic Stainless Steel Forgings

Section VIII, Division 1; Section VIII, Division 2

Approval Date: February 7, 2000

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-annealed austenitic stainless steel, 25Cr-22Ni-2Mo-N, UNS S31050 forgings meeting the chemical and mechanical property requirements given in [Table 1](#) and [Table 2](#), and otherwise conforming to the requirements of Specification SA-182, as applicable, be used in welded construction under the rules of Section VIII, Divisions 1 and 2?

Reply: It is the opinion of the Committee that the material listed in the Inquiry may be used in welded construction under the rules of Section VIII, Divisions 1 and 2, provided the following additional requirements are met.

(a) The forgings shall be solution annealed at a minimum temperature of 1925°F and liquid quenched to a temperature below 500°F.

(b) The rules for austenitic stainless steels in Section VIII, Divisions 1 and 2, as applicable, shall apply.

(c) The maximum allowable design stress values for Division 1 shall be those listed in [Table 3](#). The maximum design stress intensity values, and yield strength values, for Division 2 shall be those listed in [Table 4](#).

(d) For external pressure design, use Fig. HA-2 of Section II, Part D for both Divisions 1 and 2.

(e) This material is classified as P-No. 8 Group 2.

(f) This Case number shall be referenced in the documentation of the material and recorded on the Manufacturer's Data Report.

**Table 1
Chemical Requirements (Heat Analysis)**

Element	Weight, %
Carbon, max.	0.025
Manganese, max.	2.00
Phosphorus, max.	0.020
Sulfur, max.	0.015
Silicon, max.	0.4
Nickel	20.5–23.5
Chromium	24.0–26.0
Molybdenum	1.6–2.6
Nitrogen	0.09–0.15

**Table 2
Mechanical Property Requirements**

Property	ksi
Tensile strength, min.	78
Yield strength, 0.2% offset, min.	37
Elongation in 2 in., min., %	25

**Table 3
Maximum Allowable Stress Values, Division 1**

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi [Note (1)]
100	22.3
200	21.0, 22.0 [Note (2)]
300	19.1, 20.8 [Note (2)]
400	17.8, 20.0 [Note (2)]
500	16.8, 19.5 [Note (2)]
600	15.9, 19.0 [Note (2)]

NOTES:

(1) See Note G5 of Table 1A in Section II, Part D.

(2) The revised criterion of 3.5 on tensile strength was used in establishing these values.

**Table 4
Design Stress Intensity and Yield Strength Values, Division 2**

For Metal Temperature Not Exceeding, °F	Design Stress Intensity Values, S_m , ksi Forgings	Yield Strength Values, S_y , ksi
100	24.7	37.0
200	24.7	31.5
300	24.3	28.6
400	23.4	26.7
500	22.7	25.2
600	21.5	23.9

Case 2055-2

Pneumatic Testing of Pressure Vessels, UG-20

Section VIII, Division 1

Approval Date: May 4, 1999

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may pressure vessels, fabricated under the provisions of Section VIII, Division 1, be tested pneumatically in lieu of the hydrostatic test set forth in UG-20(f)(2)?

Reply: It is the opinion of the Committee that pneumatic test provisions of UG-100 and the requirements of UG-20(f) may be used provided the following additional requirements are met:

(a) The test pressure is at least 1.3 MAWP but shall not exceed 1.3 times the basis for calculated test pressure defined in Appendix 3-2;

(b) The MAWP is no greater than 500 psi;

(c) The following thickness limitations shall apply:

(1) For butt joints, the nominal thickness at the thickest welded joint shall not exceed $\frac{1}{2}$ in.

(2) For corner or lap welded joints, the thinner of the two parts joined shall not exceed $\frac{1}{2}$ in.

(d) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: The vessel(s) should be tested in such a manner as to ensure personnel safety from a release of the total energy of the vessel(s).

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Case 2063-6

Ni-22Cr-14W-2Mo-La Alloy (UNS N06230)

Section I

Approval Date: October 2, 2008

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-annealed alloy UNS N06230 wrought plate, sheet, strip, bar, welded pipe and tube, wrought fittings, seamless pipe and tube, and forgings conforming to the specifications listed in Table 1 be used in water service in welded construction under Section I?

Reply: It is the opinion of the Committee that solution-annealed alloy UNS N06230 wrought plate, sheet, strip, rod, welded pipe and tube, wrought fittings, seamless pipe and tube, and forgings as described in the Inquiry may be used in water wetted service in welded construction complying with the rules of Section I provided the following additional requirements are met:

(a) The maximum allowable stress values for the material shall be those given in Tables 2 and 2M. For welded pipe, tube, and fitting products, a joint efficiency factor of 0.85 shall be used.

(b) Welded fabrication shall conform to the applicable requirements of Section I. When welding is performed with filler metal of the same nominal composition as the base metal, only GMAW or GTAW processes are allowed.

(c) Welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(d) Heat treatment after forming or welding is neither required nor prohibited. When heat treatment is applied, the temperature, time, and method of heat treatment shall be covered by agreement between the user and manufacturer.

(e) For Section I, which requires a temperature-dependent parameter, y [see PG-27.4, Note (6)], the y values shall be 0.4.

(f) This Case number shall be referenced in the documentation of the material and recorded on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual coldwork. Concentration of corrosive agents (e.g. chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Product Specifications

Bar	SB-572
Forgings	SB-564
Plate, sheet, and strip	SB-435
Seamless pipe and tube	SB-622
Welded pipe	SB-619
Welded tube	SB-626
Wrought fittings	SB-366

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi [Note (1)]
-20 to 100	30.0, 30.0
200	28.2, 30.0 [Note (2)]
300	26.4, 30.0 [Note (2)]
400	24.7, 30.0 [Note (2)]
500	23.1, 30.0 [Note (2)]
600	22.0, 29.4 [Note (2)]
650	21.5, 29.1 [Note (2)]
700	21.2, 28.7 [Note (2)]
750	21.0, 28.4 [Note (2)]
800	20.9, 28.2 [Note (2)]
850	20.9, 28.2 [Note (2)]
900	20.9, 28.2 [Note (2)]
950	20.9, 28.2 [Note (2)]
1,000	20.9, 28.2 [Note (2)]

NOTES:

- (1) These values are based on the use of a tensile strength criterion of 3.5.
- (2) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 2M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa [Note (1)]
-30 to 40	207, 207
65	201, 207 [Note (2)]
100	193, 207 [Note (2)]
125	187, 207 [Note (2)]
150	182, 207 [Note (2)]
175	176, 207 [Note (2)]
200	171, 207 [Note (2)]
225	166, 207 [Note (2)]
250	161, 207 [Note (2)]
275	157, 206 [Note (2)]
300	154, 204 [Note (2)]
325	150, 202 [Note (2)]
350	148, 200 [Note (2)]
375	146, 198 [Note (2)]
400	145, 196 [Note (2)]
425	144, 194 [Note (2)]
450	144, 194 [Note (2)]
475	144, 194 [Note (2)]
500	144, 194 [Note (2)]
525	144, 194 [Note (2)]
550	144 [Note (3)], 194 [Note (2)], [Note (3)]

NOTES:

- (1) These values are based on the use of a tensile strength criterion of 3.5.
- (2) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (3) The maximum use temperature is 538°C; the value listed as 550°C is provided for interpolation purposes only.

Case 2073-1 SA-487 Grade CA6NM Class A

Section I

Approval Date: October 29, 1999

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May high alloy ferrous steel castings conforming to SA-487 Grade CA6NM Class A be used in welded construction under Section I?

Reply: It is the opinion of the Committee that castings described in the Inquiry may be used in welded construction complying with the rules of Section I, provided the following additional requirements are met:

(a) The maximum allowable stress values shall be as shown in [Table 1](#). A casting quality factor in accordance with PG-25 shall be applied to these allowable stresses except as otherwise proved in PG-42.

(b) Welded fabrication shall conform to the applicable requirements in Section I.

(1) The welding procedure and performance qualifications shall be conducted as prescribed in Section IX for P-No. 6 Group 4 material.

(2) The postweld heat treatment of welds shall be in accordance with PW-39 and [Table 2](#) of this Code Case.

(c) This Case number shall be shown on the Data Report.

Table 1
Maximum Allowable Stress Values

For Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi [Note (1)]
-20 to 100	31.4
200	31.4
300	30.8
400	30.0
500	29.4
600	28.8
650	28.5
700	28.0

NOTE: (1) The allowable stress values are based on the revised criterion of tensile strength at temperature divided by 3.5, where applicable.

Table 2
Mandatory Requirements For Postweld Heat Treatment of Pressure Parts and Attachments

Material	Holding Temperature Range, °F	Minimum Holding Time at Temperature for Weld Thickness (Nominal)			
		½ in. or less	Over ½ in. to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No.6	1050–1150	30 min.	1 hr./in.	1 hr./in.	5 hrs. plus 15 min. for each additional inch over 5 in.

Case 2093

A439 Type D-2 Austenitic Ductile Iron

Section VIII, Division 1

Approval Date: June 19, 1990

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May Type D-2 austenitic ductile iron castings conforming to ASTM A439-83 be used in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that Type D-2 austenitic ductile iron castings conforming to ASTM A439-83 may be used in Section VIII, Division 1 construc-

tion provided the following additional requirements are met.

(a) The rules in Section VIII, Division 1, that apply are those in Part UCI, except for UCI-5.

(b) The maximum allowable stress value in tension shall be 5.4 ksi; maximum metal temperature shall not exceed 450°F. (This value is less than $\frac{1}{10}$ of the room temperature specified minimum tensile strength.)

(c) This Case number shall be included in the Manufacturer's Data Report.

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Case 2120-1

Nickel-Iron-Chromium-Molybdenum-Copper Low Carbon Alloy (UNS N08926) for Code Construction

Section VIII, Division 1

Approval Date: October 29, 1999

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May austenitic nickel-base alloy (UNS N08926) sheet, strip, plate, bar, fittings, welded pipe and tube, and seamless pipe and tube that meet the chemical composition and mechanical property requirements in Table 1 and 2, and otherwise conforming to the requirements of SB-625, SB-649, SB-462, SB-366, SB-673, SB-674, and SB-677, respectively, be used in Section VIII, Division 1, welded construction?

Reply: It is the opinion of the Committee that Ni-Fe-Cr-Mo-Cu low carbon alloy (UNS N08926) plate, sheet, strip, plate, bar, fittings, welded pipe and tube, and seamless pipe and tube as described in the Inquiry may be used in Section VIII, Division 1 construction provided the following additional requirements are met.

(a) The maximum allowable stress values for the material shall be those given in Table 3. For welded pipe, welded tubing, and welded fittings, the stress values shall be multiplied by a factor of 0.85.

(b) For pipe and tube sizes larger than those listed in ASTM B677 seamless pipe and ASTM B673 welded pipe, the dimensional requirements of ASTM B464 shall be used. The maximum nominal pipe size and wall thickness are 30 and 0.5 in., respectively.

(c) The material shall be considered as P-No. 45.

(d) Heat treatment during or after fabrication is neither required nor prohibited. All other requirements in Part UNF for nickel-base alloys shall be required.

(e) For external pressure design, Fig. NFN-9 of Section II, Part D shall be used.

(f) This Case number shall be shown on the documentation and marking of the material and recorded in the Manufacturer's Data Report.

**Table 1
Chemical Composition**

Element	Composition, %
Carbon, max.	0.020
Manganese, max.	2.00
Phosphorus, max.	0.03
Sulfur, max.	0.01
Silicon, max.	0.5
Nickel	24.00–26.00
Chromium	19.00–21.00
Molybdenum	6.0–7.0
Copper	0.5–1.5
Nitrogen	0.15–0.25
Iron	Balance

**Table 2
Mechanical Property Requirements (All Product Forms)**

Tensile strength, min., ksi	94.0
Yield strength, min., ksi	43.0
Elongation in 2 in., or 4D min., %	35

**Table 3
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Stress Values, ksi [Note (1)]
100	26.9
200	24.1, 26.9 [Note (2)]
300	21.5, 26.2 [Note (2)]
400	19.7, 24.8 [Note (2)]
500	18.7, 23.7 [Note (2)]
600	18.0, 22.8 [Note (2)]
650	17.7, 22.4 [Note (2)]
700	17.5, 22.0 [Note (2)]
750	17.4, 21.6 [Note (2)]

NOTES:

- (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.
- (2) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $\frac{2}{3}$, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Case 2127-3

Type 304LN (Alloy UNS S30453) Austenitic Stainless Steel

Section VIII, Division 1

Approval Date: September 18, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed Type 304LN (Alloy UNS S30453) plate, sheet, strip, bar, forgings, fittings, seamless and welded tubing, and pipe conforming to SA-182, SA-240, SA-213, SA-312, SA-376, and SA-479, and SA-965 be used in welded and unwelded construction under Section VIII, Division 1?

Reply: It is the opinion of the Committee that solution annealed Type 304LN (Alloy UNS S30453) plate, sheet, strip, bar, forgings, fittings, seamless and welded tubing, and pipe as described in the Inquiry may be used in Section VIII, Division 1 construction provided.

(a) The material meets the chemical analysis and minimum tensile requirements detailed in the Inquiry and specifications.

(b) The Maximum Design Temperature does not exceed 100°F.

(c) The requirements, limitations and maximum allowable design stress values [limited in accordance with (b)] given in Part UHA and Table 1A of Section II, Part D, applicable to solution annealed Type 304 (Alloy UNS S30400) are used for this material.

(d) The provisions of UW-2(b)(1) permitting Type No. 2 joints for Category A welds in Type 304 material are also applicable to this material.

(e) The testing requirements of UHA-51(b)(5)(-d) shall be applicable to all welding processes used for this material.

(f) For external pressure use Fig. HA-1 of Section II, Part D.

(g) When the material's chemical analysis requirements of Table 1 are met, the exemption from base material impact testing in UHA-51 will be applicable at minimum design metal temperatures of -452°F and warmer.

(h) The exemption from Vessel (Production) Test Plates of UHA-51 may be considered to be applicable to Type 304LN material at minimum design metal temperatures of -452°F and warmer where all of the following conditions are satisfied:

(1) The chemistry requirements of Table 1 are met.

(2) The deposited filler material meets the requirements of Table 2.

(3) The welding processes used are limited to Gas Tungsten Arc (GTAW) and Plasma Arc (PAW).

(4) Each lot of filler metal shall be subject to delta ferrite determination by the method provided in SFA-5.9. In order to be acceptable, the delta ferrite calculated in conjunction with Figure 1 shall be not less than FN 2 nor greater than FN 7; and

(5) The following requirements are applied in lieu of those of UG-84(h). The fracture toughness of the welds and heat affected zone of the procedure qualification test plates shall be determined by testing in accordance with ASTM E1820 and shall demonstrate at -452°F an equivalent fracture toughness $K_{c}(J)$ of at least $120\text{ksi}\cdot\sqrt{\text{in.}}$ determined from the test data using the expression $K_{c}(J) = (EJ_{Ic})^{1/2}$. The specimens shall meet the orientation and location requirements of UG-84(g)(1) and UG-84(g)(2). Welding procedures for use only with base material less than 0.099 in. thickness are exempt from these fracture toughness testing requirements.

(i) This Case number shall be referenced in the documentation and marking of the material and recorded on the Manufacturer's Data Report.

Table 1
Chemical Requirements of Base Metal Heat Analysis

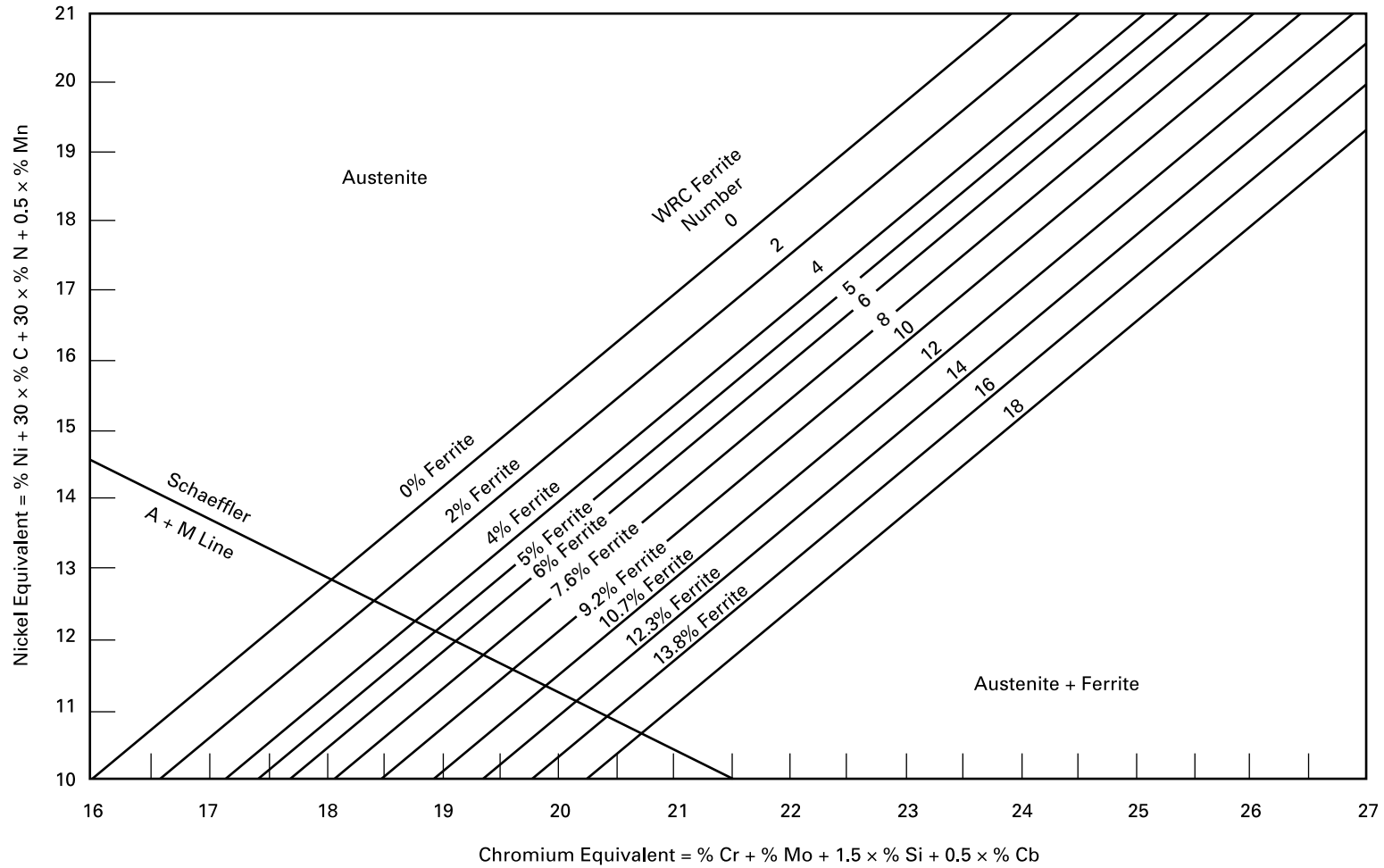
Element	Weight, %
Carbon, max.	0.030
Manganese	[Note (1)]
Phosphorus, max.	0.025
Sulfur, max.	0.015
Silicon	[Note (1)]
Nickel	[Note (1)]
Chromium	[Note (1)]
Nitrogen	0.13-0.16
Other Elements	[Note (1)]

NOTE: (1) Chemical requirements are the same as listed in the applicable material form specifications.

Table 2
Chemical Requirements of Filler Metal Deposit Analysis

Element	Weight, %
Carbon, max.	0.03
Manganese	1.00-2.5
Phosphorus, max.	0.03
Sulfur, max.	0.02
Silicon	0.30-0.50
Chromium	18.00-19.00
Nickel	12.00-14.00
Molybdenum	2.0-2.5
Nitrogen	0.035-0.060
Copper, max.	0.5

Figure 1
Delta Ferrite Content



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GENERAL NOTE: The actual nitrogen content is preferred. If this is not available, the following applicable nitrogen value shall be used:
 GMAW welds: 0.08% (except self-shielding flux cored electrode GMAW welds: 0.12%).
 (2) welds of other process: 0.06%

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Case 2142-6

F-Number Grouping for Ni-Cr-Fe Filler Metals

Section I; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX

Approval Date: August 1, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternate rules may be applied to grouping UNS N06052, UNS N06054, UNS N06055, and UNS N06056 Ni-Cr-Fe welding filler metals meeting the chemical requirements of [Table 1](#) but otherwise conforming to AWS 5.14 to reduce the number of welding procedure and performance qualifications?

Reply: It is the opinion of the Committee that UNS N06052, UNS N06054, UNS N06055, and UNS N06056 Ni-Cr-Fe welding filler metals meeting the chemical requirements of [Table 1](#) but otherwise conforming to AWS A5.14 may be considered as F-No. 43 for both procedure and performance qualification purposes. Further, these materials shall be identified as UNS N06052, UNS N06054, UNS N06055, and UNS N06056 in the Welding Procedure Specification, Procedure Qualification Record, and Performance Qualification Records.

This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	52 Composition, UNS N06052, %	52M Composition, UNS N06054, %	52MSS Composition, UNS N06055, %	52i Composition, UNS N06056, %
Carbon	0.04	0.04	0.03	0.055
Manganese	1.00	1.00	1.00	2.5-4.0
Phosphorus	0.02	0.02	0.02	0.02
Sulfur	0.015	0.015	0.015	0.015
Silicon	0.50	0.50	0.50	0.50
Chromium	28.0-31.5	28.0-31.5	28.5-31.0	26.0-28.0
Molybdenum	0.50	0.50	3.0-5.0	...
Nickel	Balance	Balance	52.0-62.0	Balance
Niobium (Columbium) plus Tantalum	0.10	0.5-1.0	2.1-4.0	2.0-2.8
Aluminum	1.10	1.10	0.50	0.60
Aluminum and Titanium	1.50	1.50	...	...
Copper	0.30	0.30	0.30	0.30
Iron	7.0-11.0	7.0-11.0	Balance	2.0-3.0
Titanium	1.0	1.0	0.50	0.40
Other elements	0.50	0.50	0.50	0.50

GENERAL NOTE: Maximum values unless range or minimum is indicated.

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Case 2143-2

F-Number Grouping for Ni-Cr-Fe, Classification UNS W86152 and UNS W86056 Welding Electrodes

Section I; Section II, Part A; Section II, Part B; Section II, Part C; Section II, Part D; Section IV; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX; Section X; Section XII; Section III, Division 1; Section XI, Division 1

Approval Date: April 1, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternate rules may be applied to grouping UNS W86152 and UNS W86056 Ni-Cr-Fe welding electrodes meeting the chemical and mechanical properties of [Tables 1](#) and [2](#) but otherwise conforming to AWS A5.11 to reduce the number of welding procedure and performance qualifications?

Reply: It is the opinion of the Committee that UNS W86152 and UNS W86056 Ni-Cr-Fe welding electrodes meeting the chemical and mechanical properties of [Tables 1](#) and [2](#) but otherwise conforming to AWS A5.11/A5.11M may be considered as F-No. 43 for both procedure and performance qualification purposes. Further, these materials shall be identified as UNS W86152 or UNS W86056, as appropriate, in the Welding Procedure Specification, Procedure Qualification Record, and Performance Qualification Records.

This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %	
	UNS W86152	UNS W86056
Carbon, max.	0.05	0.055
Manganese, max.	5.00	2.5–4.5
Phosphorus, max.	0.030	0.02
Sulfur, max.	0.015	0.015
Silicon, max.	0.75	0.50
Chromium	28.0–31.5	26.0–28.0
Molybdenum, max.	0.50	...
Nickel	Bal.	Bal.
Columbium	1.0–2.5	2.0–3.6
Aluminum, max.	0.50	0.60
Copper, max.	0.50	0.3
Iron	7.0–12.0	2.0–3.0
Titanium, max.	0.50	0.40
Other Elements, max.	0.50	0.50

Table 2
Mechanical Property Requirements
(All Weld Metal Tension Test)

Property	UNS W86152	UNS W86056
Tensile strength, min., ksi	80	90
Elongation in 2 in., min., %	30	30

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Case 2146

24Cr-17Ni-6Mn-4.5Mo-N, UNS S34565, Austenitic Stainless Steel Forgings, Bar, Fittings, Welded and Seamless Pipe and Tube, Plate, Sheet, and Strip

Section VIII, Division 1

Approval Date: November 25, 1992

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed austenitic stainless steel, 24Cr-17Ni-6Mn-4.5Mo-N, UNS S34565, forgings, bar, fittings, welded and seamless pipe and tube, plate, sheet and strip, meeting the chemical and mechanical property requirements given in [Tables 1](#) and [2](#), and otherwise conforming to the requirements of specifications of SA-182, SA-213, SA-240, SA-249, SA-312, SA-376, SA-403, SA-409, and SA-479, as applicable, be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material listed in the Inquiry may be used in welded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met.

(a) The material shall be furnished in the solution annealed condition consisting of holding at a temperature in the range from 2,050°F to 2,140°F for a time ranging from 15–30 minutes, followed by water quenching, or rapid cooling by other means.

(b) The rules for austenitic stainless steels given in Part UHA shall apply.

(c) The maximum allowable design stress values shall be those listed in [Table 3](#).

(d) For external pressure design, use [Figure 1](#), the tabular values are listed in [Table 4](#).

(e) Separate welding procedure and performance qualifications shall be conducted for the material in accordance with Section IX.

(f) Postweld heat treatment after forming or fabrication is neither required nor prohibited, but when heat treatment is performed, it shall be as in (a) above.

(g) This Case number shall be referenced in the documentation of the material and recorded on the Manufacturer's Data Report.

**Table 1
Chemical Requirements**

Element	Weight, %
Carbon, max.	0.03
Manganese	5.0–7.0
Phosphorus, max.	0.030
Sulfur, max.	0.010
Silicon, max.	1.0
Nickel	16.0–18.0
Chromium	23.0–25.0
Molybdenum	4.0–5.0
Nitrogen	0.4–0.6
Columbium, max.	0.1

**Table 2
Mechanical Properties Requirements**

Yield strength, min., 0.2% offset, ksi	60
Tensile strength, min., ksi	115
Elongation in 2 in., min., %	35

**Table 3
Maximum Allowable Stress Values, ksi**

For Metal Temperature Not Exceeding, °F	Forgings, Bar, Plate, Sheet, Strip, Seamless Pipe and Tube, Fittings	Welded Pipe and Tube, Welded Fittings [Note (1)]
100	28.8	24.5
200	28.4	24.1
300	26.9	22.9
400	25.9	22.0
500	25.3	21.5
600	25.0	21.3
650	24.8	21.1
700	24.6	20.9
750	24.3	20.7

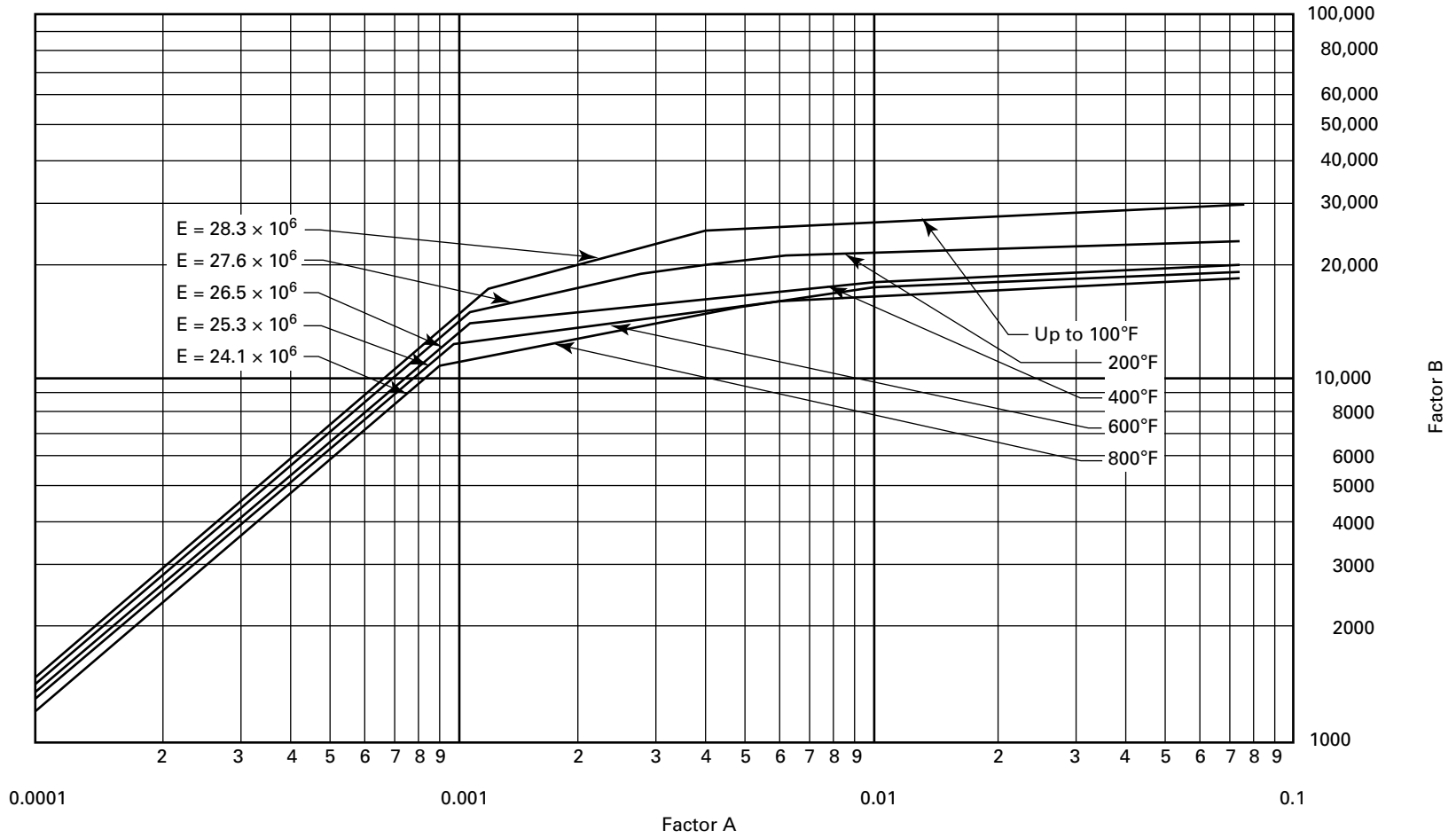
NOTE: (1) A quality factor of 0.85 has been applied in arriving at the allowable stress values for this material.

**Table 4
Tabular Values for Figure 1**

Up to 100°F, $E = 28.3 \times 10^6$ psi		Temp. 200°F, $E = 27.6 \times 10^6$ psi		Temp. 400°F, $E = 26.5 \times 10^6$ psi		Temp. 600°F, $E = 25.3 \times 10^6$ psi		Temp. 800°F, $E = 24.1 \times 10^6$ psi	
A	B, psi	A	B, psi	A	B, psi	A	B, psi	A	B, psi
1.00 -04	1,416	1.00 -04	1,382	1.00 -04	1,327	1.00 -04	1,267	1.00 -04	1,207
1.25 -03	17,715	1.11 -03	15,324	1.08 -03	14,340	9.79 -04	12,400	8.84 -04	10,673
2.24 -03	21,848	2.76 -03	19,702	3.23 -03	16,464	3.77 -03	15,781	2.28 -03	13,723
4.01 -03	26,572	6.14 -03	21,891	6.78 -03	18,057	8.38 -03	17,885	5.90 -03	16,773
9.49 -03	28,344	1.64 -02	22,985	1.80 -02	19,651	2.41 -02	19,201	1.21 -03	17,789
4.29 -02	29,997	5.63 -02	23,697	7.47 -02	20,819	7.50 -02	20,163	2.19 -02	18,450
7.50 -02	31,107	5.72 -02	24,080	...	...	...	...	5.55 -02	19,314
...	...	7.50 -02	24,463	...	...	...	...	7.50 -02	19,713

Figure 1

Chart for Determining Shell Thickness of Cylindrical and Spherical Vessels Under External Pressure When Constructed of Austenitic Stainless Steel UNS S34565



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Case 2150

Large-End Cone-to-Cylinder Junction for $30 < \alpha \leq 60$ Degrees

Section VIII, Division 1

Approval Date: August 12, 1993

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Where radiography of a circumferential joint is not required, may a cone without a knuckle at the large end of the cone-to-cylinder junction having a half-apex angle α greater than 30 deg be used in the construction of a vessel complying with the Section VIII, Division 1 rules without the special analysis specified in 1-5(g)?

Reply: It is the opinion of the Committee that when radiography of a circumferential joint is not required, a cone without a knuckle at the large end of a cone-to-cylinder junction having a half-apex angle α greater than 30 deg may be used for Section VIII, Division 1 construction without the special analysis specified in 1-5(g), provided:

(a) Equations (1) and (2) and Figures 1 and 2 given below shall be used for calculating the localized stress at the discontinuity.

$$\sigma_{\theta} = \frac{PR}{t} \left(1 - Y \sqrt{\frac{R}{t}} \right) \quad (1)$$

$$\sigma_x = \frac{PR}{t} \left(0.5 + X \sqrt{\frac{R}{t}} \right) \quad (2)$$

where

σ_{θ} = membrane hoop stress plus average discontinuity hoop stress, psi

σ_x = membrane longitudinal stress plus discontinuity longitudinal stress due to bending, psi

X, Y = factors taken from Figure 1 or 2 (or tabular values taken from Table 1 or 2)

P = internal pressure, psi

R = inside radius of the cylinder at large end of cone, in.

t = cylinder thickness, in.

(b) The half-apex angle α is not greater than 60 deg.

(c) The axial forces come solely from internal pressure acting on the closed ends. When other loads (such as wind loads, dead loads, etc.) are involved, the design shall be in accordance with U-2(g).

(d) σ_{θ} shall not be greater than $1.5S$ and σ_x shall not be greater than $3S$ where S is the maximum allowable stress value, in psi, obtained from the applicable table of stress values in Section II, Part D.

(e) After the required thickness for the shell has been determined by UG-27(c), and that for the cone by UG-32(g), the stress limits of (d) above must be checked with eqs. (a)(1) and (a)(2) using the calculated required thicknesses. If the limits of (d) are not met, the shell and cone thicknesses near the junction must be increased so that the limits of (d) are met. When additional thickness is required, the section of increased thickness shall extend a minimum distance from the junction as shown in Figure 3.

(f) The angle joint between the cone and cylinder shall be designed equivalent to a double butt-welded joint and there shall be no weak zones around the joint.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
X and Y For Cone Thickness = t

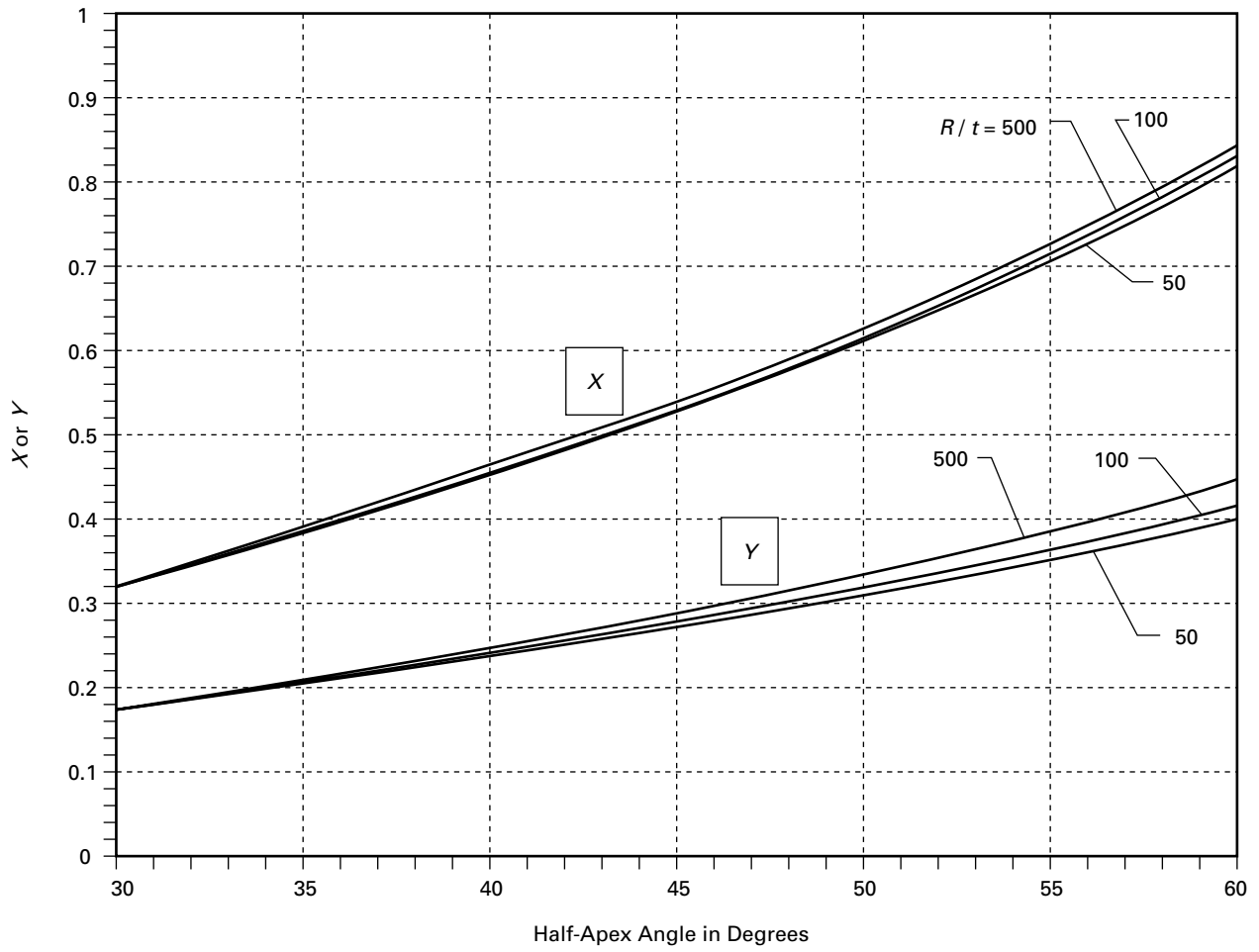


Figure 2
X and Y For Cone Thickness = $t/\cos \alpha$

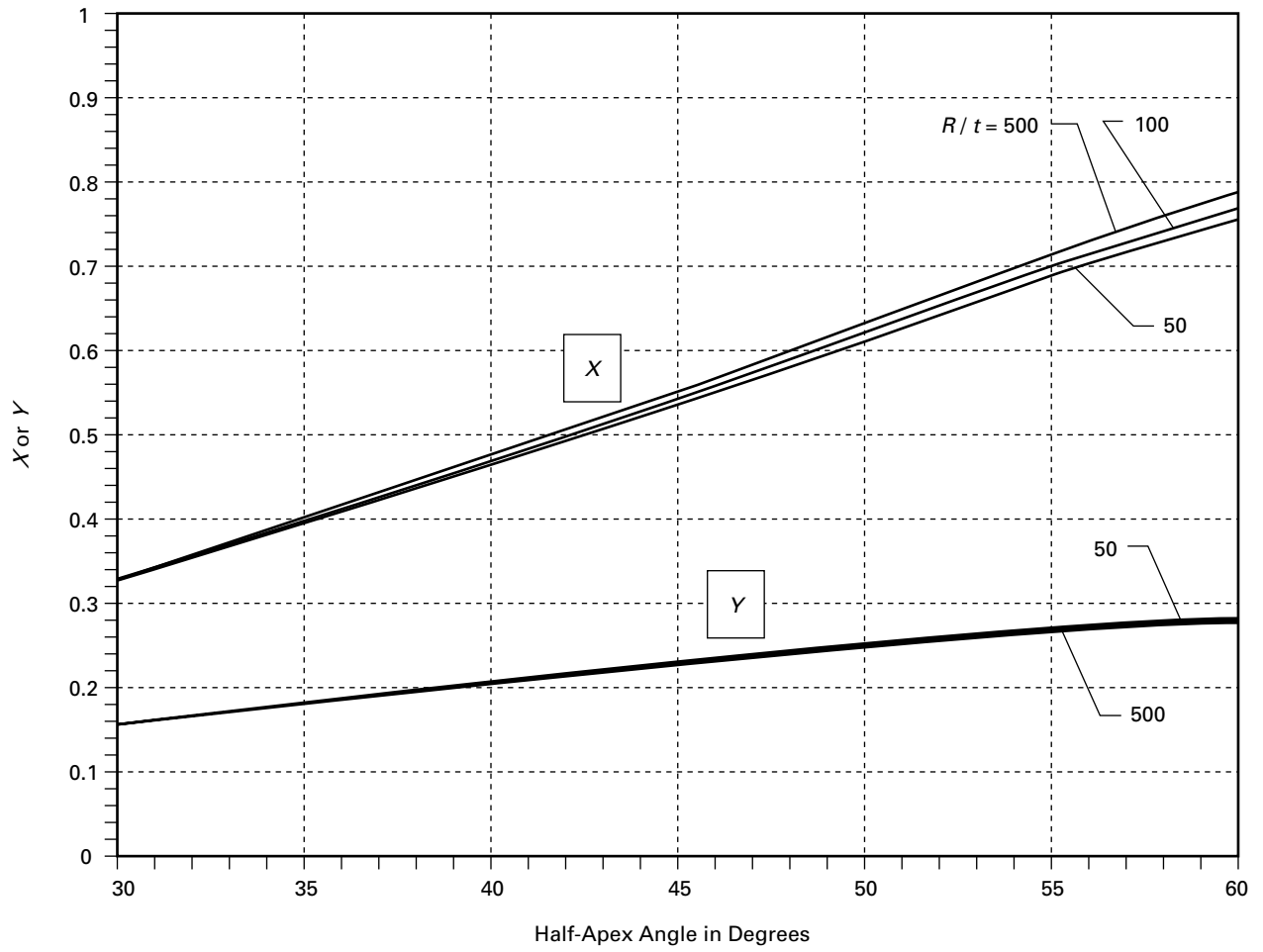


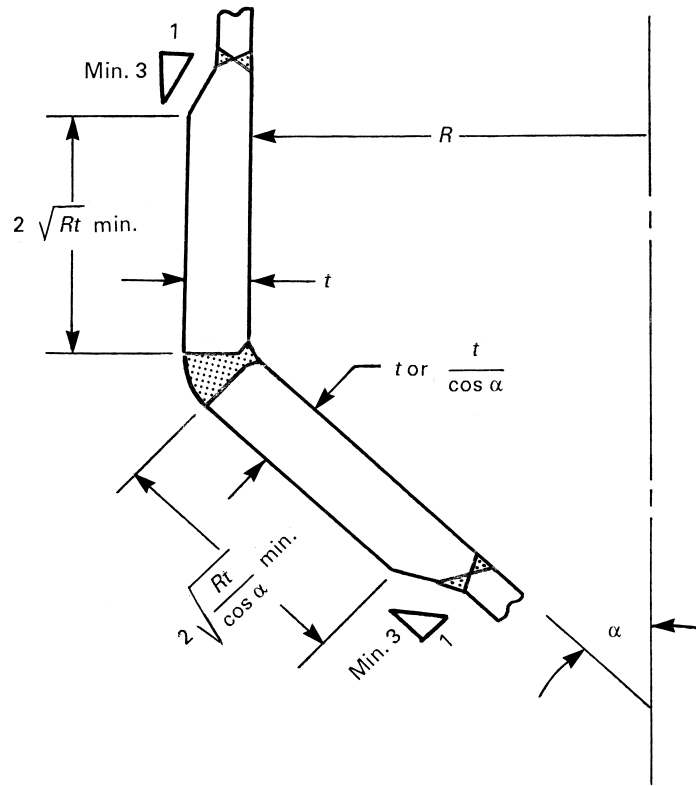
Table 1
Tabular Values for Figure 1

Half-Apex Angle, deg	Y			X		
	R/t = 500	R/t = 100	R/t = 50	R/t = 500	R/t = 100	R/t = 50
30	0.1750	0.1721	0.1698	0.3239	0.3211	0.3182
31	0.1822	0.1788	0.1762	0.3378	0.3348	0.3317
32	0.1894	0.1854	0.1826	0.3517	0.3484	0.3451
33	0.1966	0.1921	0.1890	0.3655	0.3621	0.3586
34	0.2038	0.1987	0.1955	0.3794	0.3758	0.3720
35	0.2110	0.2054	0.2019	0.3933	0.3894	0.3855
36	0.2182	0.2121	0.2083	0.4072	0.4031	0.3990
37	0.2254	0.2187	0.2147	0.4211	0.4168	0.4124
38	0.2327	0.2254	0.2211	0.4349	0.4304	0.4259
39	0.2399	0.2320	0.2275	0.4488	0.4441	0.4393
40	0.2471	0.2387	0.2339	0.4627	0.4578	0.4528
41	0.2543	0.2454	0.2403	0.4766	0.4714	0.4663
42	0.2615	0.2520	0.2468	0.4905	0.4851	0.4797
43	0.2687	0.2587	0.2532	0.5043	0.4988	0.4932
44	0.2759	0.2653	0.2596	0.5182	0.5124	0.5066
45	0.2831	0.2720	0.2660	0.5321	0.5261	0.5201
46	0.2918	0.2799	0.2733	0.5493	0.5432	0.5369
47	0.3005	0.2878	0.2806	0.5665	0.5604	0.5537
48	0.3092	0.2958	0.2878	0.5836	0.5775	0.5704
49	0.3179	0.3037	0.2951	0.6008	0.5947	0.5872
50	0.3266	0.3116	0.3024	0.6180	0.6118	0.6040
51	0.3365	0.3204	0.3104	0.6379	0.6314	0.6232
52	0.3464	0.3291	0.3183	0.6577	0.6509	0.6423
53	0.3563	0.3379	0.3263	0.6776	0.6705	0.6615
54	0.3662	0.3466	0.3342	0.6974	0.6900	0.6806
55	0.3761	0.3554	0.3422	0.7173	0.7096	0.6998
56	0.3877	0.3654	0.3512	0.7411	0.7322	0.7217
57	0.3993	0.3754	0.3602	0.7649	0.7548	0.7436
58	0.4110	0.3854	0.3691	0.7887	0.7773	0.7654
59	0.4226	0.3954	0.3781	0.8125	0.7999	0.7873
60	0.4342	0.4054	0.3871	0.8363	0.8225	0.8092

Table 2
Tabular Values for Figure 2

Half-Apex Angle, deg	Y			X		
	R/t = 500	R/t = 100	R/t = 50	R/t = 500	R/t = 100	R/t = 50
30	0.1601	0.1604	0.1613	0.3325	0.3297	0.3264
31	0.1646	0.1650	0.1660	0.3468	0.3437	0.3402
32	0.1691	0.1696	0.1708	0.3611	0.3578	0.3539
33	0.1735	0.1742	0.1755	0.3754	0.3718	0.3677
34	0.1780	0.1788	0.1802	0.3897	0.3858	0.3815
35	0.1825	0.1834	0.1849	0.4040	0.3998	0.3952
36	0.1870	0.1880	0.1897	0.4183	0.4139	0.4090
37	0.1915	0.1926	0.1944	0.4326	0.4279	0.4228
38	0.1959	0.1972	0.1991	0.4468	0.4419	0.4365
39	0.2004	0.2018	0.2038	0.4611	0.4559	0.4503
40	0.2049	0.2064	0.2086	0.4754	0.4700	0.4641
41	0.2094	0.2110	0.2133	0.4897	0.4840	0.4778
42	0.2139	0.2156	0.2180	0.5040	0.4980	0.4916
43	0.2183	0.2202	0.2227	0.5183	0.5120	0.5054
44	0.2228	0.2248	0.2275	0.5326	0.5261	0.5191
45	0.2273	0.2294	0.2322	0.5469	0.5401	0.5329
46	0.2309	0.2331	0.2359	0.5627	0.5555	0.5479
47	0.2345	0.2367	0.2397	0.5786	0.5709	0.5628
48	0.2382	0.2404	0.2434	0.5944	0.5864	0.5778
49	0.2418	0.2440	0.2472	0.6103	0.6018	0.5927
50	0.2454	0.2477	0.2509	0.6261	0.6172	0.6077
51	0.2484	0.2508	0.2540	0.6422	0.6325	0.6224
52	0.2515	0.2538	0.2572	0.6583	0.6479	0.6371
53	0.2545	0.2569	0.2603	0.6744	0.6632	0.6518
54	0.2576	0.2599	0.2635	0.6905	0.6786	0.6665
55	0.2606	0.2630	0.2666	0.7066	0.6939	0.6812
56	0.2628	0.2652	0.2688	0.7215	0.7078	0.6942
57	0.2649	0.2673	0.2710	0.7365	0.7217	0.7073
58	0.2671	0.2695	0.2733	0.7514	0.7356	0.7203
59	0.2692	0.2716	0.2755	0.7664	0.7495	0.7334
60	0.2714	0.2738	0.2777	0.7813	0.7634	0.7464

Figure 3



Case 2151-3

3 Chromium-1 Molybdenum- $\frac{1}{4}$ Vanadium-Columbium-Calcium Alloy Steel Plates and Forgings for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible in the construction of welded pressure vessels conforming to the requirements of Section VIII, Division 2 for Class 2, to use steel plates and forgings with chemical, tensile, and toughness requirements as described in applicable material specifications of Section II, Part A, tempered at minimum temperature of 1,250°F (675°C) after normalizing or quenching, but otherwise conforming to the requirements of one of the specifications listed in [Table 1](#)?

Reply: It is the opinion of the Committee that the materials specified in the Inquiry may be used in the construction of welded vessels under the rules of Section VIII, Division 2 for Class 2, provided the following additional requirements are met.

(a) The maximum design metal temperature shall not exceed 900°F (482°C).

(b) *Mechanical Properties*

(1) The maximum allowable stress values, *S*, for Division 2, for Class 2 shall be as listed in [Table 2](#) and [Table 2M](#).

(2) The physical properties in Section II, Part D shall apply.

(3) The stress-strain curve in Annex 3-D.3 of Section VIII, Division 2 for Class 2 shall apply.

(4) The design fatigue curve in Section VIII, Division 2, Annex 3-F shall apply. The interpolation using 552 MPa (80 ksi) curve, and 793 MPa to 892 MPa (115 ksi to 130 ksi) curve may be applicable.

(5) For external pressure applications, use Section II, Part D, Figure CS-3.

(c) The final postweld heat treatment shall be in accordance with the requirements of Division 2 for Class 2 for P-No. 5C Grade 1 material.

(d) The supplemental requirements for Cr-Mo steels in Section VIII, Division 2, 3.4, except 3.4.4.5 shall apply.

(e) Welding shall be limited to the submerged-arc (SAW), the shielded metal-arc (SMAW), and the gas tungsten-arc (GTAW) processes.

(f) All applicable requirements of Section II, Part D, Subpart 1, Table 5A, if appropriate, shall apply except as otherwise provided above.

(g) This Case number shall be referenced in the documentation of the material and recorded on the Manufacturer's Data Report.

Table 1
Material Specifications

Specification	Grade	Material
SA-182	F3Vcb	Forgings
SA-336	F3Vcb	Forgings
SA-508	3Vcb	Forgings
SA-541	3Vcb	Forgings
SA-542	Type E, Class 4a	Plates
SA-832	23V	Plates

Table 2
Maximum Stress Values, *S*, for Class 2

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, <i>S</i> , ksi
600	35.4
650	34.8
700	34.1
750	33.3
800	31.2
850	25.8
900	21.0

GENERAL NOTES:

- (a) Allowable stress for 800°F and above are values obtained from time-dependent properties.
- (b) The allowable stress values for temperatures of 800°F and above are the same values provided for 3Cr-1Mo- $\frac{1}{4}$ V-Ti-B, which is similar to 3Cr-1Mo- $\frac{1}{4}$ V-Cb-Ca, except that the creep strength of 3Cr-1Mo- $\frac{1}{4}$ V-Cb-Ca alloy is slightly higher than that of 3Cr-1Mo- $\frac{1}{4}$ V-Ti-B.

Table 2M
Maximum Stress Values, *S*, for Class 2

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, <i>S</i> , MPa
300	244
325	243
350	239
375	234
400	229
425	223
450	183
475	153
500 [Note (1)]	125

GENERAL NOTES:

- (a) Allowable stress for 450°C and above are values obtained from time-dependent properties.
- (b) The allowable stress values for temperatures of 425°C and above are the same values provided for 3Cr-1Mo- $\frac{1}{4}$ V-Ti-B, which is similar to 3Cr-1Mo- $\frac{1}{4}$ V-Cb-Ca, except that the creep strength of 3Cr-1Mo- $\frac{1}{4}$ V-Cb-Ca alloy is slightly higher than that of 3Cr-1Mo- $\frac{1}{4}$ V-Ti-B.

NOTE: (1) The value provided at 500°C is for interpolation only. See (a).

Case 2172

Use of B43 Seamless Red Brass Pipe (UNS C23000) With Drawn General Purpose Temper (H58) for Threaded Piping for Construction of PMB and PEB Miniature Electric Boilers

Section I

Approval Date: August 8, 1994

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May seamless red brass pipe (UNS C23000) manufactured to Specification B43 with drawn general purpose (H58) temper be used for threaded piping for Section I, PMB and PEB miniature electric boilers?

Reply: It is the opinion of the Committee that B43 seamless red brass pipe (UNS C23000) with drawn general purpose (H58) temper may be used for threaded piping for Section I, PMB and PEB miniature electric boilers provided the following additional requirements are met.

(a) The seamless red brass pipe meets all other requirements in Section II, Part B, Specification SB-43 except for temper.

(b) Stress values for design shall be those provided in Table 1B of Section II, Part D, SB-43, UNS C23000 for the annealed condition (O61).

(c) Operating temperatures do not exceed 406°F, as stipulated in para. PG-9.3.

(d) A warning label shall be provided stating that ammonia or ammonium compounds shall not be permitted to come into contact with the external or internal surface of the pipe. The label shall be attached to the boiler near the feed water inlet connections.

(e) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: This material is sensitive to stress corrosion cracking in certain aqueous environments.

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Case 2179-12

9Cr-2W, UNS K92460 Material

Section I; Section VIII, Division 1

Approval Date: May 12, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 9Cr-2W, UNS K92460 material conforming to one of the specifications listed in [Table 1](#) be used for Section I and Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that 9Cr-2W, UNS K92460 material conforming to one of the specifications listed in [Table 1](#) may be used for Section I and Section VIII, Division 1 construction, provided the following additional requirements are met:

(a) SA-369, FP92 material shall not exceed Brinell Hardness of 250 HBW/265 HV (25 HRC).

(b) The maximum allowable stress values, the tensile strength values, and the yield strength values for the material shall be those given in [Tables 2 and 2M, 3 and 3M, 4 and 4M](#), respectively. The maximum use temperature for the material shall be 1,200°F (649°C).

(c) For the purposes of procedure and performance qualifications, the material shall be considered P-No. 15E Group 1. The procedure and performance qualifications shall be conducted in accordance with Section IX. Procedure and performance qualifications qualified under previous versions of this Case do not require requalification.

(1) When weld filler metal of nominally matching chemistry (e.g., AWS B92, etc.) is used to make pressure-retaining welds in these materials, the nickel plus manganese (Ni + Mn) content of the filler metal shall not exceed 1.2%.

(2) Postweld heat treatment for this material is mandatory, and the following rules shall apply:

(-a) The time requirements shall be those given for P-No. 15E, Group 1 materials in [Tables PW-39-5 for Section I and Table UCS-56-11 for Section VIII, Division 1](#).

(-b) The PWHT temperature range shall be 1,350°F to 1,470°F (730°C to 800°C).

(-c) Exemptions to postweld heat treatment for this material shall be in accordance with the rules for P-No. 15E, Group 1 materials in [Table PW-39-5 for Section I and Table UCS-56-11 for Section VIII, Division 1](#).

(d) For Section VIII, Division 1 applications, all requirements of Subsection C, Part UCS shall apply.

(e) Repair welding of base material shall be permitted as prescribed by the applicable material product specification or its general requirements specification. Repair welding of base material shall be performed using procedures and welders or welding operators that have been qualified in accordance with Section IX and with one of the following welding processes: SMAW, SAW, GTAW, and FCAW. The composition of the welding consumables shall be such that the lower critical transformation temperature of the consumables shall exceed the maximum postweld heat treatment temperature in para. (c)(2)(-b). If the lower critical transformation temperature is calculated rather than measured, the formula used shall be reported. If requested, data supporting the validity of the formula shall be provided to the Manufacturer. All repair welds to base material shall be normalized and tempered according to the requirements of the applicable material product specification.

(f) Except as provided in (e), if during the manufacturing any portion of the component is heated to a temperature greater than 1,470°F (800°C), then the component must be reaustenitized and retempered in its entirety in accordance with the applicable material specification, or that portion of the component heated above 1,470°F (800°C), and at least 3 in. (75 mm) on either side of the overheated zone must be replaced, or must be removed, reaustenitized, and retempered, and then replaced in the component.

(g) If the allowable stress values to be used are less than or equal to those provided in Section II, Part D, Table 1A for Grade 9 (SA-213 T9, SA-335 P9, or equivalent product specifications) at the design temperature, then the requirements of para. (e) may be waived, provided that the portion of the component heated to a temperature greater than 1,470°F (800°C) is reheat-treated within the temperature range 1,350°F to 1,425°F (730°C to 775°C). If this provision is exercised, it shall be noted on the Manufacturer's Data Report.

(h) Formed areas of vessel shell sections, heads, and other pressure boundary parts of this material shall be heat treated as follows:

(1) For Section I, forming strains shall be calculated using the equations of PG-19. For Section VIII, Division 1, forming strains (extreme fiber elongations) shall be calculated using the equations of Table UG-79-1. When the forming strains cannot be calculated as shown in

Section I, PG-19 or Section VIII, Division 1, Table UG-79-1, the Manufacturer shall have the responsibility to determine the maximum forming strain, except as limited by (2) and (3)(-a).

(2) *Hot-Forming.* For any hot-formed product form, the material shall be normalized and tempered in accordance with (3)(-d), regardless of the amount of strain. Hot-forming is defined as any forming that is performed at or above the temperature of 1,300°F (705°C) and produces permanent strain in the material.

(3) *Cold-Forming.* Cold-forming is defined as any forming that is performed at a temperature below 1,300°F (705°C) and produces permanent strain in the material.

(-a) For cold-formed flares, swages, or upsets in tubing or pipe, the material shall be normalized and tempered in accordance with (-f) regardless of the amount of strain.

(-b) For design temperatures exceeding 1,000°F (540°C) but less than or equal to 1,115°F (600°C), and cold-forming strains greater than 25%, the material shall be normalized and tempered in accordance with (-f).

(-c) For design temperatures exceeding 1,115°F (600°C) and cold-forming strains greater than 20%, the material shall be normalized and tempered in accordance with (-f).

(-d) For design temperatures exceeding 1,000°F (540°C) but less than or equal to 1,115°F (600°C), and cold-forming strains greater than 5% but less than or equal to 25%, the material shall be heat treated in accordance with (-g), (-h), or (-i).

(-e) For design temperatures exceeding 1,115°F (600°C), and cold-forming strains greater than 5% but less than or equal to 20%, the material shall be heat treated in accordance with (-g) or (-i).

(-f) Normalization shall be performed in accordance with the requirements of the applicable material specification and shall not be performed locally. The material shall either be heat treated in its entirety, or the cold-strained area (including the transition to the undeformed portion) shall be cut away from the balance of the component and heat treated separately, or replaced.

(-g) Post cold-forming heat treatment shall be performed at 1,350°F to 1,425°F (730°C to 775°C) for 1 hr./in. (1 h/25 mm) or 30 min minimum. Alternatively, the material may be normalized and tempered in accordance with (-f).

(-h) For design temperatures less than or equal to 1,115°F (600°C) and cold-forming strains greater than 5% but less than or equal to 25%, if a portion of the component is heated above the post-forming heat treatment, then either the component shall be normalized and tempered according to (-f), or (g) shall apply.

(-i) If a longitudinal weld is made to a portion of the material that is cold-strained, that portion shall be normalized and tempered in accordance with (-f).

(i) This material is a creep strength-enhanced ferritic (CSEF) steel whose creep temperature strength is enhanced by the creation of a precise condition of microstructure, specifically martensite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbonitrides, or other stable and/or metastable phases. Refer to Section I, PW-10 for additional cautionary information

CSEF alloys may demonstrate a susceptibility to creep-intolerant behavior, which manifests as limited amount of plastic deformation at the time of creep-rupture.

(j) This Case number shall be shown on the Manufacturer's Data Report and in the certification and marking of the material.

CAUTION: This material has demonstrated a susceptibility to creep cavity formation and damage in the time-dependent regime resulting in very low strain before rupture and high sensitivity to multiaxial stresses (e.g., trending to notch weakening behavior). The accumulation of creep damage is known to contribute to a decreased life expectancy.

Table 1
Material Specifications and Grades

Materials	Specifications
Fittings (seamless)	SA-234 WP92
Flanges, fittings, valves, and parts	SA-182 F92
Forged and bored pipe	SA-369 FP92
Forgings	SA-336 F92
Plate	SA-1017/SA-1017M Grade 92
Seamless pipe	SA-335 P92
Seamless tubes	SA-213 T92

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	ksi
-20 to 100	25.7
200	25.7
300	25.3
400	24.5
500	23.8
600	23.2
650	22.8
700	22.4
750	21.9
800	21.4
850	20.8
900	20.1
950	19.2
1,000	18.3
1,050	15.4 [Note (1)]
1,100	11.7 [Note (1)]
1,150	8.3 [Note (1)]
1,200	5.3 [Note (1)]

NOTE: (1) These stress values are obtained from time-dependent properties.

Table 2M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	MPa
-30 to 40	177
85	177
100	177
125	177
150	174
200	169
250	165
300	161
325	159
350	156
375	154
400	151
425	148
450	144
475	140
500	135
525	129
550	123
575	97.5 [Note (1)]
600	75.0 [Note (1)]
625	54.3 [Note (1)]
650 [Note (1)]	35.8 [Note (1)]

NOTES:

- (1) These stress values are obtained from time-dependent properties.
- (2) The maximum use temperature is 649°C. The value at 650°C is provided for interpolation purposes only.

**Table 3
Tensile Strength Values**

For Metal Temperature Not Exceeding, °F	ksi
-20 to 100	90.0
200	84.0
300	80.6
400	77.9
500	75.8
600	73.7
650	72.5
700	71.2
750	69.8
800	68.0
850	66.1
900	63.8
950	61.2
1,000	58.1
1,050	54.6
1,100	50.6
1,150	46.1
1,200	40.9

**Table 4
Yield Strength Values**

For Metal Temperature Not Exceeding, °F	ksi
-20 to 100	64.0
200	61.0
300	59.7
400	58.9
500	58.2
600	57.3
650	56.6
700	55.7
750	54.7
800	53.4
850	51.7
900	49.7
950	47.4
1,000	44.5
1,050	41.2
1,100	37.4
1,150	33.0
1,200	28.0

**Table 3M
Tensile Strength Values**

For Metal Temperature Not Exceeding, °C	MPa
-30 to 40	621
85	621
100	621
125	621
150	610
200	592
250	577
300	563
325	556
350	547
375	539
400	528
425	517
450	504
475	489
500	472
525	452
550	429
575	404
600	376
625	344
650	309

**Table 4M
Yield Strength Values**

For Metal Temperature Not Exceeding, °C	MPa
-30 to 40	441
85	428
100	419
125	415
150	411
200	406
250	402
300	397
325	393
350	389
375	383
400	377
425	368
450	359
475	347
500	333
525	316
550	297
575	276
600	251
625	223
650	191

Case 2180-9

Seamless 11Cr-2W Material

(25)

Section I

Approval Date: February 3, 2025

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 11Cr-2W seamless tubes, seamless pipes, plate, and forgings that conform to the specifications listed in [Table 1](#) be used for Section I construction?

Reply: It is the opinion of the Committee that 11Cr-2W seamless tubes, seamless pipes, plate, and forgings that conform to the specifications listed in [Table 1](#) may be used for Section I construction, provided the following requirements are met:

(a) The maximum allowable stress values for the material shall be those given in [Tables 2](#) and [2M](#).

(b) Separate welding procedure qualifications shall be conducted in accordance with Section IX. For purposes of performance qualification, this material shall be considered P-No. 15F. Procedures and performance qualifications qualified under previous versions of this Case do not require requalification, provided that the maximum PWHT temperature shown on the WPS is limited to that prescribed by [\(c\)\(2\)](#) or [\(c\)\(3\)](#) as applicable.

(c) Postweld heat treatment (PWHT) for this material is mandatory, and the following rules shall apply:

(1) The time requirements shall be those given for P-No. 15E, Group 1 materials in [Tables PW-39-5](#).

(2) The PWHT temperature range shall be 1,350°F to 1,445°F (730°C to 785°C) if grade 91 type consumables are used (e.g., -B91 or ISO CrMo91). All -B91 and ISO CrMo91 filler metals shall be limited to 1.2% max. Mn + Ni.

(3) For weld consumables other than grade 91 mentioned in [\(2\)](#) above, experimental measurement of the weld deposit's lower critical temperature (LCT) on a heat-lot basis shall be determined before use. The experimental measurement shall be performed in accordance with a relevant standard. The maximum permitted PWHT temperature shall not exceed the lesser of 1,470°F (800°C) or the weld deposit's LCT. The minimum PWHT shall be 1,350°F (730°C).

(d) Postforming heat treatment shall comply with the same requirements as indicated in Section I, PG-20.2 for Grade 91 material.

(e) Except as provided in [\(1\)](#), [\(2\)](#), and [\(f\)](#) if during the manufacturing any portion of the component is heated to a temperature greater than 1,470°F (800°C), then the component must be reaustenitized and retempered in its entirety in accordance with the product specification or that portion of the component heated above 1,470°F (800°C), including the overheated zone created by the local heating, must be replaced, or must be removed, reaustenitized, and retempered, and then replaced in the component.

(1) For components with weld deposits, the following requirement shall apply when the PWHT temperature has locally exceeded the temperature limit defined in [\(c\)\(2\)](#) or [\(c\)\(3\)](#) as applicable but has not exceeded 1,470°F (800°C). The entire weld deposit shall be removed and rewelded followed by PWHT.

(2) Alternatively, a section including the weld zone and an appropriate length of material on either side of the weld zone must be replaced, or, removed, reaustenitized and retempered in accordance with the product specification except the retempering parameters shall additionally meet the applicable PWHT limitations of [\(c\)\(1\)](#) through [\(c\)\(3\)](#).

(f) If the design stress values to be used are less than or equal to the allowable stress values provided in [Table 1A](#) of Section II, Part D for Grade 9 (SA-213 T9, SA-335 P9, or equivalent product specifications) at the design temperature, then the requirements of [\(e\)](#), as applicable, may be waived provided that the portion of the component overheated is reheat treated within the temperature range 1,350°F to 1,425°F (730°C to 775°C) but not to exceed the LCT of any weld deposits.

(g) This material is a Creep Strength-Enhanced Ferritic (CSEF) steel, whose creep temperature strength is enhanced by the creation of a precise condition of microstructure, specifically tempered martensite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbo-nitrides, or other stable and/or meta-stable phases. Refer to PW-10 of Section I for additional cautionary information. CSEF alloys may demonstrate a susceptibility to creep-intolerant behavior, which manifests as limited amount of plastic deformation at the time of creep-rupture.

(h) This Case number shall be shown in the material certification and marking of the material.

(i) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: This material has demonstrated a susceptibility to creep cavity formation and damage in the time-dependent regime resulting in very low strain before rupture and high sensitivity to multiaxial stresses (e.g., trending to notch weakening behavior). The accumulation of creep damage is known to contribute to a decreased life expectancy.

**Table 1
Specifications**

Forgings	SA-182/SA-182M, F122
Pipe	SA-335/SA-335M, P122
Plate	SA-1017/SA-1017M, Grade 122
Tube	SA-213/SA-213M, T122

**Table 2
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
-20 to 100	25.7
200	25.7
300	25.0
400	24.2
500	23.7
600	23.1
650	22.9
700	22.5
750	22.1
800	21.6
850	21.1
900	20.3
950	19.5
1,000	18.5
1,050	14.4
1,100	10.4 [Note (1)]
1,150	6.8 [Note (1)]
1,200	4.5 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

**Table 2M
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
-28 to 40	177
65	177
100	177
125	175
150	172
175	170
200	167
225	165
250	164
275	162
300	160
325	159
350	157
375	155
400	152
425	149
450	146
475	141
500	137
525	131
550	118
575	90.3 [Note (1)]
600	65.6 [Note (1)]
625	44.2 [Note (1)]
650 [Note (2)]	30.3 [Note (1)]

NOTES:

- (1) These values are obtained from time-dependent properties.
- (2) The maximum use temperature is 649°C. The value at 650°C is provided for interpolation purposes only.

Case 2192-11

9Cr-1Mo-V Material, UNS J84090

Section I

Approval Date: October 4, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 9Cr-1Mo-V material, UNS J84090, with the chemical composition shown in [Table 1](#), the mechanical properties shown in [Table 2](#), and otherwise conforming to applicable requirements of Section II, Part A: SA-217/SA-217M, Grade C12A be used for Section I construction?

Reply: It is the opinion of the Committee that 9Cr-1Mo-V material, UNS J84090, having the chemical requirements shown in [Table 1](#) and room temperature mechanical property requirements shown in [Table 2](#), may be used in Section I construction provided the following requirements are met:

(a) The material shall meet the chemical analysis and minimum tensile requirements described in the Inquiry, and shall otherwise meet the requirements of SA-217/SA-217M, as applicable.

(b) The casting shall be inspected in accordance with the requirements of Supplementary Requirements S5 (Radiographic Inspection) or S7 (Ultrasonic Inspection), as described in ASTM A703. The choice of method shall be at the option of the material manufacturer unless otherwise stated in the purchase order.

(c) The material shall be austenitized within the temperature range of 1,900°F to 1,975°F (1040°C to 1080°C), followed by air or accelerated cooling¹ to a temperature of 200°F (95°C) or below, followed by tempering within the range of 1,350°F to 1,470°F (730°C to 800°C). However, if a major weld repair, as defined in SA-217/SA-217M, para. 9.4 is made to SA-217/SA-217M castings after the austenitizing and tempering heat treatment, then a new austenitizing and tempering heat treatment in accordance with the requirements of this subparagraph shall be carried out.

(d) When heat treating single castings, compliance with the specified temperature range shall be verified by thermocouples placed directly on the casting. For castings that are heat treated in batches, compliance with the specified temperature range shall be verified by thermocouples

placed on selected castings in each heat treatment batch. The number and location of thermocouples to be placed on each casting, or on each heat treatment batch of castings, for verification of heat treatment shall be as agreed between the purchaser and the producer. A record of the final austenitizing and tempering heat treatment and any subsequent subcritical heat treatment, to include both the number and location of thermocouples applied to each casting, or to each heat treatment batch of castings, shall be prepared and made available to the purchaser. In addition, all heat treatment temperatures and cycle times for the final austenitizing and tempering heat treatment and any subsequent subcritical heat treatment shall be shown on the certification report.

(e) The hardness of the cast material after the final heat treatment shall be Brinell Hardness Number 185 – 248 HBW (Rockwell B90 – Rockwell C25).

(f) The maximum allowable stress values for the material shall be those given in [Tables 3](#) and [3M](#).

(g) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. This material shall be considered P-No. 15E, Group 1.

(h) Weld repairs to castings or cast pipe shall be made with one of the following welding processes and consumables:

(1) SMAW, SFA-5.5/SFA-5.5M E90XX-B91

(2) SAW, SFA-5.23/SFA-5.23M EB91 + neutral flux

(3) GTAW, SFA-5.28/SFA-5.28M ER90S-B91

(4) FCAW, SFA-5.29/SFA-5.29M E91T1-B91

In addition, the Ni + Mn content of all welding consumables shall not exceed 1.0%.

(i) Weld repairs to castings or cast pipe as part of material manufacture shall be made with welding procedures and welders qualified in accordance with Section IX.

(j) All weld repairs shall be recorded with respect to their location on the casting. For all major weld repairs, as defined in SA-217/SA-217M, para. 9.4, the record shall include a description of the length, width, and depth of the repair. Supplementary Requirement S12 of ASTM A703 shall apply. For weld repairs performed as part of material manufacture, the documentation shall be included with the Material Test Report. For weld repairs performed by the Manufacturer, documentation shall be included with the Manufacturer's Data Report.

¹To facilitate complete transformation to martensite after the austenitizing, cooling should be as uniform as possible.

(k) Except as provided in (l) if during the manufacturing any portion of the component is heated to a temperature greater than 1,470°F (800°C), then the component must be re-austenitized and retempered in its entirety in accordance with (c), or that portion of the component heated above 1,470°F (800°C), including the Heat-Affected Zone created by the local heating, must be replaced, or must be removed, re-austenitized, and retempered, and then replaced in the component.

(l) If the allowable stress values to be used are less than or equal to those provided in Table 1A of Section II, Part D for Grade 9 (SA-217/SA-217M, Grade C12; or equivalent product specifications) at the design temperature, then the requirements of (k) may be waived, provided the portion of the component heated to a temperature greater than 1,470°F (800°C) is reheat treated within the temperature range 1,350°F to 1,425°F (730°C to 775°C). Use of this waiver shall be recorded on the Manufacturer's Data Report.

(m) A manufacturer's test report meeting certification requirements of SA-703/SA-703M shall be provided.

(n) This Case number shall be shown in the material certification and marking of the material.

(o) This Case number shall be shown on the Manufacturer's Data Report.

(p) Allowable stresses for temperatures $\geq 1,000^\circ\text{F}$ ($\geq 550^\circ\text{C}$) shown in Tables 3 and 3M, respectively, represent those obtained from time-dependent properties.

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.08–0.12
Manganese	0.30–0.60
Phosphorus, max.	0.020
Sulfur, max.	0.010
Silicon	0.20–0.50
Chromium	8.00–9.50
Molybdenum	0.85–1.05
Nickel, max.	0.40
Vanadium	0.18–0.25
Columbium	0.06–0.10
Nitrogen	0.03–0.07
Aluminum, max.	0.02
Titanium, max.	0.01
Zirconium, max.	0.01

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength, min., ksi (MPa)	85 (585)
Yield strength, min., ksi (MPa)	60 (415)
Elongation in 2 in. (50 mm), min., %	18

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	24.3
200	24.3
300	23.5
400	22.8
500	22.2
600	21.7
650	21.4
700	21.0
750	20.5
800	20.0
850	19.3
900	18.5
950	17.7
1,000	14.3
1,050	11.3
1,100	8.6
1,150	5.7
1,200	3.5

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	167
65	167
100	167
125	165
150	162
200	158
250	154
300	151
325	149
350	147
375	144
400	141
425	138
450	134
475	129
500	124
525	109
550	89.2
575	71.1
600	54.3
625	36.8
650 [Note (1)]	24.0

NOTE: (1) The maximum design temperature is 649°C. The value provided at 650°C is for interpolation purposes only.

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Case 2195-1

24.5Cr-22Ni-7.5Mo-3Mn-N Austenitic Stainless Steel (UNS S32654)

Section VIII, Division 1

Approval Date: February 7, 2000

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed alloy UNS S32654 wrought sheet, strip, plate, seamless and welded pipe, forgings, fittings, and welded tubing, with chemical composition conforming to [Table 1](#), room temperature mechanical properties conforming to [Table 2](#) and otherwise conforming to the specifications SA-240, SA-312, SA-182, SA-403, and SA-249 respectively, be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the committee that solution annealed alloy UNS S32654 as described in the inquiry, may be used in welded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met.

(a) The rules of Section VIII, Division 1, Subsection C that shall apply are given in part UHA for austenitic stainless steels.

(b) The maximum allowable stress values for the material shall be those given in [Table 3](#). For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used for circumferential stress design.

(c) Separate welding procedure qualifications and performance qualifications, conducted in accordance with Section IX, shall be required for this material.

(d) For external pressure design, use Fig. HA-2 of Section II, Part D to a maximum temperature of 800°F.

(e) The minimum solution annealing temperature shall be 2100°F, to be followed by quenching in water or rapidly cooled by other means.

(f) Post-weld heat treatment after forming or fabrication is neither required nor prohibited, but when heat treatment is performed, it shall be as noted in (e).

(g) ENiCrMo-3 and ERNiCrMo-3 or similar corrosion resistant weld filler metals may be used to weld UNS S32654 materials.

(h) This Case number shall be shown on the documentation and marking of the material and on the Manufacturer's Data Report.

**Table 1
Chemical Requirements**

Element	Composition, %
Carbon, max.	0.020
Manganese	2.00-4.00
Phosphorous, max.	0.030
Sulfur, max.	0.005
Silicon, max.	0.50
Chromium	24.00-25.00
Nickel	21.00-23.00
Molybdenum	7.00-8.00
Copper	0.30-0.60
Nitrogen	0.45-0.55
Iron	Balance

**Table 2
Mechanical Test Requirements (Room Temperature)**

Tensile strength, ksi	109
Yield strength, 0.2% offset, ksi	62
Elongation in 2 in., min., %	35.0

**Table 3
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi [Note (1)]
75/100	31.1
200	31.1
300	30.3
400	28.5
500	27.3
600	26.6
650	26.4
700	26.3
750	26.1
800	25.9

NOTE: (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.

Case 2196-5

Austenitic Stainless Steel Seamless Tubes and Pipe, Seamless Wrought Fittings, Plate, Sheet, and Forgings, 18Cr-11Ni-Cb-N, UNS S34751, 347LN

Section VIII, Division 1

Approval Date: April 2, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed stainless steel seamless tubes and pipe, seamless wrought fittings, plate, sheet, and forgings, UNS S34751, 347LN, with the seamless tubes and pipe meeting the requirements of SA-213 TP347LN and SA-312 TP347LN, respectively; and the seamless wrought fittings, plate, sheet, and forgings with chemical compositions conforming to [Table 1](#), mechanical properties conforming to [Tables 2](#) and [3](#), and otherwise conforming to the applicable requirements of SA-182, SA-240, SA-403, and SA-965 be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that solution-annealed austenitic stainless steel seamless tubes and pipe, seamless wrought fittings, plate, sheet, and forgings, UNS S34751, 347LN, as described in the Inquiry, may be used in welded construction under the rules of Section VIII, Division 1, provided that the following additional requirements are met:

(a) The seamless tubes and pipe shall meet the requirements of SA-213 TP347LN and SA-312 TP347LN, respectively.

(b) The seamless wrought fittings, plate, sheet, and forgings shall meet the chemical analysis of [Table 1](#) and the minimum tensile requirements of [Tables 2](#) and [3](#), and shall otherwise meet the requirements of SA-182, SA-240, SA-403, and SA-965, as applicable, except as shown in paras. (d) and (e).

(c) The rules of Section VIII, Division 1, Subsection C, Part UHA for austenitic stainless steels shall be met. The post-fabrication heat treatment rules of UHA-44 that apply to Grade 347, UNS S34700 shall apply to this material.

(d) The seamless wrought fittings, plate, and sheet material shall be solution annealed at a minimum temperature of 1,900°F (1040°C).

(e) The hardness of the plate material shall not exceed 201 HBW (92 HRB).

(f) The yield strength and tensile strength values are shown in [Tables 4](#) and [4M](#) for seamless wrought fittings, plate, and sheet, and in [Tables 5](#) and [5M](#) for forgings.

(g) The maximum allowable stress values for the material shall be as given in [Tables 6](#) and [6M](#) for seamless wrought fittings, plate, and sheet, and in [Tables 7](#) and [7M](#) for forgings. The maximum design temperature is 1,250°F (677°C).

(h) For external pressure design, Figure HA-2 in Section II, Part D shall be used.

(i) The physical property values (modulus of elasticity, coefficients of linear thermal expansion, thermal conductivity and diffusivity, and density) shall be those shown for 18Cr-10Ni-Cb and High Alloy Steels (300 series) material in Section II, Part D, Subpart 2.

(j) The material shall be considered as P-No. 8, Group 1.

(k) This Case number shall be included in the documentation and marking of the material and in the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.005–0.020
Manganese, max.	2.00
Phosphorus, max.	0.045
Sulfur, max.	0.030
Silicon, max.	1.00
Nickel	9.0–13.0
Chromium	17.0–20.0
Columbium	0.20–0.50 [Note (1)]
Nitrogen	0.06–0.10

NOTE: (1) The material shall have a columbium content of not less than 15 times the carbon content.

Table 2
Mechanical Property Requirements for Seamless Wrought Fittings, Plate, and Sheet (Room Temperature)

Mechanical Property	Value
Tensile strength, min., ksi (MPa)	75 (515)
Yield strength, 0.2% offset min., ksi (MPa)	30 (205)
Elongation, in 2 in. (50 mm), min. %	
Fittings to SA-182	30
Fittings to SA-403	28 longitudinal, 20 transverse
Plate and Sheet	40
Reduction in Area, min. %	
Fittings to SA-182	50

Table 3
Mechanical Property Requirements for Forgings (Room Temperature)

Mechanical Property	Value
Tensile strength, min., ksi (MPa)	70 (485)
Yield strength, 0.2% offset, min., ksi (MPa)	30 (205)
Elongation, in 2 in. (50 mm), min. %	30
Reduction in area, min. %	45

Table 4
Yield Strength, S_y , and Tensile Strength, S_u , Values for
Seamless Wrought Fittings, Plate, and Sheet

For Metal Temperature Not Exceeding, °F	Yield Strength Values, ksi [Note (1)]	Tensile Strength Values, ksi [Note (2)]
100	30.0	75.0
200	26.5	73.1
300	24.0	66.9
400	21.9	62.3
500	20.4	59.3
600	19.4	57.7
650	19.1	57.4
700	18.9	57.2
750	18.7	57.1
800	18.7	57.0
850	18.6	56.9
900	18.6	56.6
950	18.6	56.2
1,000	18.6	55.4
1,050	18.5	54.4
1,100	18.3	53.1
1,150	18.1	51.3
1,200	17.8	49.3
1,250	17.0	46.1

NOTES:

- (1) See Note (B) of Table Y-1 in Section II, Part D.
(2) See Note (B) of Table U in Section II, Part D.

Table 4M
Yield Strength, S_y , and Tensile Strength, S_u , Values for
Seamless Wrought Fittings, Plate, and Sheet

For Metal Temperature Not Exceeding, °C	Yield Strength Values, MPa [Note (1)]	Tensile Strength Values, MPa [Note (2)]
40	207	517
65	192	517
100	180	498
125	172	478
150	165	461
175	158	445
200	152	432
225	147	421
250	142	412
275	138	405
300	135	400
325	133	397
350	131	395
375	130	394
400	129	394
425	129	393
450	129	392
475	129	391
500	128	389
525	128	385
550	128	380
575	127	372
600	126	363
625	124	352
650	123	339
675	117	319
700	116 [Note (3)]	300 [Note (3)]

NOTES:

- (1) See Note (B) of Table Y-1 in Section II, Part D.
(2) See Note (B) of Table U in Section II, Part D.
(3) These values are provided for interpolation purposes only. The maximum design temperature of this material is as stated in (g).

Table 5
Yield Strength, S_y , and Tensile Strength, S_u , Values for Forgings

For Metal Temperature Not Exceeding, °F	Yield Strength, S_y , Values, ksi [Note (1)]	Tensile Strength, S_u , Values, ksi [Note (2)]
100	30.0	70.0
200	23.7	62.3
300	21.1	57.6
400	19.5	54.2
500	18.5	52.2
600	17.7	51.1
650	17.4	50.8
700	17.1	50.6
750	16.8	50.5
800	16.5	50.3
850	16.2	50.1
900	15.9	49.7
950	15.7	49.1
1,000	15.5	48.3
1,050	15.4	47.3
1,100	15.3	45.9
1,150	15.2	44.2
1,200	15.2	42.2
1,250	15.1	39.9

NOTES:

- (1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).
- (2) See Section II, Part D, Subpart 1, Table U, General Note (b).

Table 5M
Yield Strength, S_y , and Tensile Strength, S_u , Values for Forgings

For Metal Temperature Not Exceeding, °C	Yield Strength, S_y , Values, MPa [Note (1)]	Tensile Strength, S_u , Values, MPa [Note (2)]
40	205	485
65	177	450
100	161	425
125	152	410
150	145	396
175	140	385
200	135	375
225	132	368
250	129	362
275	126	357
300	124	354
325	122	352
350	119	350
375	117	349
400	116	348
425	114	347
450	112	346
475	110	343
500	109	340
525	108	336
550	107	330
575	106	323
600	105	314
625	105	303
650	105	290
675	104	276
700	104	260

NOTES:

- (1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).
- (2) See Section II, Part D, Subpart 1, Table U, General Note (b).

Table 6
Maximum Allowable Stresses for Seamless Wrought Fittings, Plate, and Sheet

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi
100	20.0, 20.0
200	17.7, 20.0 [Note (1)]
300	16.0, 19.1 [Note (1)]
400	14.6, 17.8 [Note (1)]
500	13.6, 16.9 [Note (1)]
600	12.9, 16.5 [Note (1)]
650	12.7, 16.4 [Note (1)]
700	12.6, 16.3 [Note (1)]
750	12.5, 16.3 [Note (1)]
800	12.4, 16.3 [Note (1)]
850	12.4, 16.3 [Note (1)]
900	12.4, 16.2 [Note (1)]
950	12.4, 16.1 [Note (1)]
1,000	12.4, 15.8 [Note (1)]
1,050	12.3, 15.6 [Note (1)]
1,100	12.2, <i>12.9</i> [Note (2)]
1,150	<i>9.56, 9.56</i> [Note (2)]
1,200	<i>7.03, 7.03</i> [Note (2)]
1,250	<i>5.11, 5.11</i> [Note (2)]

NOTES:

- (1) See Note G5 of Section II, Part D, Table 1A.
(2) Values in italics are obtained from time dependent properties. See Note T8 of Table 1A of Section II, Part D.

Table 6M
Maximum Allowable Stresses for Seamless Wrought Fittings, Plate, and Sheet

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa
40	138, 138
65	128, 137 [Note (1)]
100	120, 137 [Note (1)]
125	115, 136 [Note (1)]
150	110, 131 [Note (1)]
175	105, 127 [Note (1)]
200	101, 123 [Note (1)]
225	97.7, 120 [Note (1)]
250	94.7, 117 [Note (1)]
275	92.2, 115 [Note (1)]
300	90.2, 114 [Note (1)]
325	88.6, 113 [Note (1)]
350	87.5, 112 [Note (1)]
375	86.7, 112 [Note (1)]
400	86.2, 112 [Note (1)]
425	85.9, 112 [Note (1)]
450	85.7, 112 [Note (1)]
475	85.7, 111 [Note (1)]
500	85.6, 111 [Note (1)]
525	85.4, 110 [Note (1)]
550	85.1, 108 [Note (1)]
575	84.7, 106 [Note (1)]
600	<i>83.0, 83.0</i> [Note (1)], [Note (2)]
625	<i>63.2, 63.2</i> [Note (2)]
650	<i>47.8, 47.8</i> [Note (2)]
675	<i>35.9, 35.9</i> [Note (2)]
700	<i>26.9, 26.9</i> [Note (2)], [Note (3)]

NOTES:

- (1) See Note G5 of Section II, Part D, Table 1A.
(2) Values in italics are obtained from time dependent properties. See Note T8 of Table 1A of Section II, Part D.
(3) This value is provided for interpolation purposes only. The maximum design temperature for this material is as stated in (g).

Table 7
Maximum Allowable Stresses for Forgings

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi
100	19.8, 19.8
200	15.8, 19.6 [Note (1)]
300	14.1, 18.1 [Note (1)]
400	13.0, 17.0 [Note (1)]
500	12.3, 16.4 [Note (1)]
600	11.8, 16.0 [Note (1)]
650	11.6, 15.7 [Note (1)]
700	11.4, 15.4 [Note (1)]
750	11.2, 15.1 [Note (1)]
800	11.0, 14.8 [Note (1)]
850	10.8, 14.6 [Note (1)]
900	10.6, 14.3 [Note (1)]
950	10.5, 14.2 [Note (1)]
1,000	10.4, 14.0 [Note (1)]
1,050	10.3, 13.9 [Note (1)]
1,100	10.2, 12.9 [Note (2)]
1,150	9.56, 9.56 [Note (2)]
1,200	7.03, 7.03 [Note (2)]
1,250	5.11, 5.11 [Note (2)]

NOTES:

- (1) See Section II, Part D, Subpart 1, Table 1A, Note G5.
- (2) These values are obtained from time-dependent properties. See Section II, Part D, Subpart 1, Table 1A, Note T8.

Table 7M
Maximum Allowable Stresses for Forgings

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa
40	137, 137
65	118, 137 [Note (1)]
100	107, 134 [Note (1)]
125	101, 129 [Note (1)]
150	96.9, 125 [Note (1)]
175	93.2, 121 [Note (1)]
200	90.3, 118 [Note (1)]
225	87.9, 116 [Note (1)]
250	85.8, 114 [Note (1)]
275	84.1, 112 [Note (1)]
300	82.5, 111 [Note (1)]
325	81.0, 109 [Note (1)]
350	79.6, 107 [Note (1)]
375	78.3, 106 [Note (1)]
400	77.0, 104 [Note (1)]
425	75.8, 102 [Note (1)]
450	74.6, 101 [Note (1)]
475	73.6, 99.3 [Note (1)]
500	72.6, 98.0 [Note (1)]
525	71.8, 96.9 [Note (1)]
550	71.1, 96.0 [Note (1)]
575	70.6, 95.3 [Note (1)]
600	70.2, 83.0 [Note (1)], [Note (2)]
625	63.2, 63.2 [Note (2)]
650	47.8, 47.8 [Note (2)]
675	35.9, 35.9 [Note (2)]
700	26.9, 26.9 [Note (2)], [Note (3)]

NOTES:

- (1) See Section II, Part D, Subpart 1, Table 1A, Note G5.
- (2) These values are obtained from time-dependent properties. See Section II, Part D, Subpart 1, Table 1A, Note T8.
- (3) This value is provided for interpolation purposes only. The maximum design temperature for this material is as stated in (g).

Case 2197-1

18.5Cr-15.5Ni-4.5Mo-N Alloy (UNS S31726)

Austenitic Stainless Steel

Section VIII, Division 1

Approval Date: February 17, 2000

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-annealed 18.5Cr-15.5Ni-4.5Mo-N alloy (UNS S31726) plate conforming to SA-240 be used in welded and unwelded construction under Section VIII, Division 1?

Reply: It is the opinion of the Committee that solution annealed 18.5Cr-15.5Ni-4.5Mo-N alloy (UNS S31726) plate, as described in the Inquiry, may be used in Section VIII, Division 1 construction provided:

(a) The material meets the chemical analysis and minimum tensile requirements detailed in the specification.

(b) Heat treatment after forming is neither required nor prohibited. If heat treatment is used, the solution heat treatment shall consist of heating to a temperature of 1,900°F min. and quenching in water or rapidly cooling by other means.

(c) The maximum allowable design stress values are those given in [Table 1](#).

(d) The welding procedure qualifications and performance qualifications shall be conducted as prescribed in Section IX. Welding shall be done by any process or combination of processes capable of meeting the require-

ments. The material shall be considered P-No. 8, Group 4. ENiCrMo-3 and ERNiCrMo-3 or similar corrosion resistant weld filler metals may be used.

(e) For external pressure design, use Section II, Part D, Fig. HA-1.

(f) The rules for austenitic stainless steels in Subsection C, Part UHA, shall apply.

(g) This Case number shall be included in the marking of the material and shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
100	22.9
200	18.8, 22.9 [Note (2)]
300	16.8, 22.6 [Note (2)]
400	15.6, 21.0 [Note (2)]
500	15.0, 20.3 [Note (2)]

NOTES:

(1) The revised criterion of 3.5 on tensile strength was used in establishing these values.

(2) Note G5 of Section II, Part D, Table 1A applies.

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Case 2199-10

2.25Cr-1.6W-V-Cb Material

Section I

Approval Date: May 12, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 2.25Cr-1.6W-V-Cb material conforming to the specifications shown in [Table 1](#) be used for Section I construction?

Reply: It is the opinion of the Committee that 2.25Cr-1.6W-V-Cb material conforming to the specifications shown in [Table 1](#) may be used for Section I construction, provided the following requirements are met:

(a) The material shall be austenitized within the temperature range of 1,900°F to 1,975°F (1040°C to 1080°C), followed by air or accelerated cooling, and tempered within the range of 1,325°F to 1,425°F (720°C to 775°C).

(b) The material shall not exceed a Brinell Hardness Number of 220 (Rockwell B 97, 230 HV) after tempering.

(c) The maximum allowable stress values for the material shall be those given in [Tables 2](#) and [2M](#).

(d) Separate weld procedure qualification shall be required for this material. The welding procedure qualification shall be conducted as prescribed in Section IX. Procedure and performance qualifications qualified under previous versions of this Case do not require requalification. Exemptions to postweld heat treatment for this material shall be in accordance with the rules for P-No. 5A materials in PW-39. When postweld heat treatment is required, the time requirements shall be in accordance with the rules for P-No. 5A materials in PW-39, and the PWHT temperature range shall be 1,325°F to 1,425°F (720°C to 775°C). For the purposes of performance qualification, the material shall be considered P-No. 5A. The performance qualification shall be conducted as prescribed in Section IX.

(e) All cold formed material with a thickness less than 1/2 in. (13 mm), which is designed for service at a nominal temperature of 900°F (480°C) or higher, shall be heat treated in accordance with the following rules. Cold bending or forming is defined as any method that produces strain in the material and is performed at a temperature below 1,125°F (605°C). The calculations of cold strains shall be made as described in Section I, PG-19.

(1) For materials with greater than 20% strain, and all cold swages, flares, or upsets regardless of the amount of cold reduction, the cold formed areas, including the transition to the unstrained portion, shall be re-austenitized and retempered, in accordance with (a). This heat treatment shall not be performed locally. The material shall either be heat treated in its entirety, or the cold strained area (including the transition) shall be cut away from the balance of the tube or component, and heat treated separately or replaced.

(2) For materials with greater than 5% strain, and less than or equal to 20% strain, the cold strained portion of the part or component shall not be exposed to temperatures between 1,325°F and 1,900°F (720°C and 1040°C) during fabrication or erection, whether purposefully or incidentally with other components. If such a cold strained area is so exposed during fabrication, the cold strained area shall be scrapped or may be salvaged by re-austenitizing and retempering, as described in (1).

(3) For material described in (2), if a weld is made to that portion of the material that is cold strained, the cold strained portion shall be re-austenitized and retempered, prior to or following welding, as described in (1) above.

(4) For materials with less than or equal to 5% strain, heat treatment is neither required nor prohibited.

(f) All bending or forming in excess of 5% strain that are performed at or above 1,125°F (605°C), or on material with a thickness equal to or greater than 1/2 in. (13 mm) shall be re-austenitized and retempered, in accordance with (a). This heat treatment shall not be performed locally. The material shall either be heat treated in its entirety, or the strained area (including the transition) shall be cut away from the balance of the tube or component, and heat treated separately or replaced. For material with less than or equal to 5% strain (e.g., as a consequence of final straightening of a component), heat treatment is neither required nor prohibited unless the hot forming temperature exceeds 1,425°F (775°C), in which case (g) is applicable.

(g) Except as provided in (h), if during the manufacturing any portion of the component is heated to a temperature greater than 1,425°F (775°C), then the component must be re-austenitized and retempered in its entirety in accordance with (a), or that portion of the component heated above 1,425°F (775°C), including

the Heat-Affected Zone created by the local heating, must be replaced, or must be removed, re-austenitized, and retempered, and then replaced in the component.

(h) If the allowable stress values to be used are less than or equal to those provided in Table 1A of Section II, Part D for Grade 22 (SA-213 T22, SA-335 P22, or equivalent product specifications) at the design temperature, then the requirements of (g) may be waived provided that the portion of the component heated to a temperature greater than 1,425°F (775°C) is reheat treated within the temperature range 1,325°F to 1,425°F (720°C to 775°C).

(i) This material is a creep strength-enhanced ferritic (CSEF) steel whose creep temperature strength is enhanced by the creation of a precise condition of microstructure, specifically martensite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbonitrides, or other

stable and/or metastable phases. Refer to Section I, PW-10 for additional cautionary information.

CSEF alloys may demonstrate a susceptibility to creep-intolerant behavior, which manifests as limited amount of plastic deformation at the time of creep-rupture.

(j) This Case number shall be shown in the documentation and marking of the material and on the Manufacturer's Data Report.

Table 1
Specifications

Forgings	SA-182 F23
Pipe	SA-335 P23
Plate	SA-1017 Grade 23
Tube	SA-213 T23

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Tubes	Forgings, Pipe, Plate
-20 to 100	21.1	21.1
200	21.1	21.1
300	21.1	21.1
400	21.1	21.1
500	21.1	21.1
600	20.9	20.9
650	20.7	20.7
700	20.5	20.5
750	20.3	20.3
800	19.9	19.9
850	19.5	19.5
900	18.9	18.9
950	17.8	16.2
1,000	14.3 [Note (1)]	13.3 [Note (1)]
1,050	11.2 [Note (1)]	10.7 [Note (1)]
1,100	8.4 [Note (1)]	8.3 [Note (1)]
1,150	5.5 [Note (1)]	5.0 [Note (1)]
1,200	1.4 [Note (1)]	1.4 [Note (1)]

NOTE: (1) These stress values are obtained from time-dependent properties.

Table 2M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Tubes	Forgings, Pipe, Plate
40	145	145
65	145	145
100	145	145
125	145	145
150	145	145
200	145	145
250	145	145
300	145	145
325	144	144
350	142	142
375	141	141
400	140	140
425	137	137
450	135	135
475	132	132
500	126	119
525	111	101
550	88.9 [Note (1)]	83.6 [Note (1)]
575	70.5 [Note (1)]	68.2 [Note (1)]
600	53.3 [Note (1)]	52.3 [Note (1)]
625	34.5 [Note (1)]	31.1 [Note (1)]
650 [Note (2)]	8.5 [Note (1)]	8.7 [Note (1)]

NOTES:

- (1) These stress values are obtained from time-dependent properties.
- (2) The maximum use temperature is 649°C. The value at 650°C is provided for interpolation purposes only.

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Case 2203-2

Omission of Lifting Device Requirements for Pressure Relief Valves on Air, Water Over 140°F (60°C), or Steam Service

Section VIII, Division 1; Section VIII, Division 2; Section XIII

Approval Date: December 7, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the lifting device specified in Section XIII, 3.2.7(a) and (b) for each pressure relief valve on air, water over 140°F (60°C), or steam service be omitted?

Reply: It is the opinion of the Committee that the requirements for a lifting device as specified in Section XIII, 3.2.7(a) and (b) may be omitted, provided:

(a) The user has a documented procedure and an associated implementation program for the periodic removal of the pressure relief valves for inspection and testing, and repair as necessary.

(b) The omission is specified by the user.

(c) The user shall obtain permission to omit the lifting device from the authority having jurisdiction over the installation of pressure vessels.

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Case 2205

Alternate Rules for Heat Treatment of Repair Welds to Castings

Section VIII, Division 1

Approval Date: June 5, 1995

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May a Certificate Holder apply Section VIII, Division 1 post weld heat treatment requirements to casting repairs in lieu of the requirements of UG-24(b)?

Reply: It is the opinion of the Committee that a Certificate Holder may apply the PWHT requirements of Section VIII, Division 1 to castings repaired by welding in lieu of the requirements of UG-24(b).

This Case number shall be identified on the Manufacturer's Data Report.

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Case 2217-5

Precipitation-Hardening Ni-Cr-Mo Alloy (UNS N07725)

Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3

Approval Date: June 17, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May precipitation-hardened Ni-Cr-Mo alloy (UNS N07725) wrought sheet, strip, plate, bar, rod, seamless pipe and tube, and forgings with chemical analyses per [Table 1](#) and minimum mechanical properties per [Table 2](#), and otherwise conforming to one of the specifications listed in [Table 3](#), be used in welded construction under the rules of Section VIII, Divisions 1, 2, and 3?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used for Section VIII, Division 1 construction at a design temperature of 1,000°F or less, and Section VIII, Division 2 construction at a design temperature of 800°F or less, provided the following additional requirements are met.

(a) The rules in Section VIII, Division 1, Subsection C, Part UNF; Division 2, Part AM; or Division 3, Part KM, as applicable for nickel alloys, shall apply.

(b) The maximum allowable stress values for Division 1 shall be those given in [Table 4](#). The design stress intensity values and yield strength values for Division 2 shall be those listed in [Table 5](#). The yield strength values for Division 3 shall be those listed in [Table 6](#).

(c) Heat treatment of the alloy shall be per the following:

Solution Anneal:	1,850–1,950°F, air cool
Age Hardening:	1,350°F (±25°F) hold for 5.5 to 8.5 hrs., furnace cool to 1,150°F (±25°F) hold for 5.5 to 8.5 hrs., air cool

(d) Separate welding procedures and performance qualifications shall be conducted in accordance with Section IX.

(e) The use of filler metal that will deposit weld metal with practically the same composition as the material joined is recommended. When the Manufacturer is of the opinion that a physically better joint can be made by departure from these limits, filler metal of a different composition may be used provided the strength of the weld metal at the operating temperature is not appreciably less than that of the high alloy material to be welded, and the user is satisfied that its resistance to corrosion is satisfactory for the intended service.

(f) Heat treatment after welding is required and shall be per (c) above.

(g) For Divisions 1 and 2, the required thickness for external pressure shall be determined from the chart in Section II, Part D, Fig. NFN-17.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition Limits, %
Nickel	55.0–59.0
Chromium	19.0–22.5
Iron [Note (1)]	Remainder
Manganese, max.	0.35
Carbon, max.	0.03
Silicon, max.	0.20
Columbium	2.75–4.00
Sulfur, max.	0.010
Phosphorus, max.	0.015
Aluminum, max.	0.35
Titanium	1.00–1.70
Molybdenum	7.00–9.50

NOTE: (1) This element shall be determined arithmetically by difference.

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength, min., ksi	150.0
Yield strength, 0.2% offset, min., ksi	120.0
Elongation, 2 in. gage or 4D, min., %	20.0

Table 3
Material Specifications

SB-443	Plate, sheet, and strip
SB-444	Seamless pipe and tube
SB-446	Rod and bar
SB-564	Forgings

Table 4
Maximum Allowable Stress Values, Division 1

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, max., ksi [Note (1)]
100	42.9
200	42.9
300	42.9
400	42.9
500	42.9
600	41.9
650	41.5
700	41.1
750	40.8
800	40.6

NOTE: (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.

Table 5
Design Stress Intensity and Yield Strength Values, Division 2

For Metal Temperature Not Exceeding, °F	Design Stress Intensity Values, S_m , ksi	Yield Strength Values, S_y , ksi
100	50.0	120.0
200	50.0	118.1
300	50.0	114.9
400	50.0	112.1
500	50.0	110.1
600	48.9	108.8
650	48.4	108.4
700	48.0	108.0
750	47.6	107.6
800	47.4	107.2
850	...	106.6
900	...	106.3
950	...	106.0
1,000	...	105.7

Table 6
Yield Strength Values, Division 3

For Metal Temperature Not Exceeding, °F	Yield Strength Values, S_y , ksi
100	120.0
200	118.1
300	114.9
400	112.1
500	110.1
600	108.8
650	108.4
700	108.0
750	107.6
800	107.2

Case 2222-2

Precipitation-Hardening Nickel Alloy (UNS N07718) Used as Pressure Retaining Component Material

Section VIII, Division 1; Section VIII, Division 2

Approval Date: October 29, 1999

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May precipitation-hardened nickel alloy rod, bar, forgings, and forging stock (UNS N07718) conforming to SB-637 be used for the construction of parts for pressure retaining components in pressure vessels of Section VIII, Divisions 1 and 2 construction?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used for Section VIII, Division 1 construction at a design temperature of 1,000°F or less, and Section VIII, Division 2 construction at a design temperature of 800°F or less, provided the following additional requirements are met.

(a) The maximum allowable stress values for use in Section VIII, Division 1 shall be those listed in [Table 1](#).

(b) The maximum design stress intensity values for use in Section VIII, Division 2 are shown in [Table 2](#).

(c) The rules of Part UNF shall apply for Section VIII, Division 1 construction and the rules of Article M-4 for Section VIII, Division 2 construction.

(d) No welding is permitted.

(e) The limiting factors for bearing and shear shall be applied on S , S_m , and S_y as applicable.

(f) Use for bolting is not permitted.

(g) This Case number shall be shown on the material certification, marking of the material, and on the Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in the sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Maximum Allowable Stress Values, ksi

For Metal Temperature Not Exceeding, °F	Max. Allowable Stress Values, ksi [Note (1)]
100	52.9
200	52.9
300	52.9
400	52.9
500	52.9
600	52.9
650	52.9
700	52.6
750	52.5
800	52.3
850	52.2
900	52.0
950	51.6
1,000	51.0

NOTE: (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.

Table 2
Design Stress Intensity Values
and Yield Stress Values, ksi

For Metal Temperature Not Exceeding, °F	Yield Stress, ksi	Max. Design Stress Intensity Values, ksi
100	150.0	61.7
200	144.4	61.7
300	140.6	61.7
400	138.2	61.7
500	136.6	61.7
600	135.5	61.7
650	135.0	61.7
700	134.5	61.4
750	133.8	61.2
800	133.1	61.1

Case 2223-3

Use of SA-705 Type 630 Forgings (UNS S17400) and SA-693 Type 630 Plate (UNS S17400)

(25)

Section VIII, Division 1; Section VIII, Division 2

Approval Date: June 20, 2002

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May martensitic precipitation hardened stainless steel, 17Cr-4Ni-4Cu (UNS S17400) forgings complying with SA-705 Type 630, and plate, sheet, and strip complying with SA-693 Type 630, be used for pressure vessels constructed under Section VIII, Divisions 1 and 2?

Reply: It is the opinion of the Committee that martensitic precipitation hardened stainless steel, 17Cr-4Ni-4Cu (UNS S17400) forgings, plate, sheet, and strip conforming to the requirements of SA-705 Type 630, and plate, sheet, and strip complying with SA-693 Type 630, may be used for pressure vessels constructed under Section VIII, Divisions 1 and 2, provided the following additional requirements are met.

(a) The material shall be in the H1100 or H1150 condition for Division 1 and in the H1150 condition for Division 2.

(b) The maximum allowable design stress values for Division 1 shall be those listed in Table 1. The maximum design stress intensity values for Division 2 shall be those listed in Table 2.

(c) No welding is permitted, except nonpressure parts may be welded to the pressure vessel provided the following rules are observed.

(1) Welding shall be performed on the UNS S17400 pressure part only in the H1150 condition.

(2) The weld metal shall be the same nominal composition as UNS S17400.

(3) After welding, the welded component shall be fully solution annealed and aged to the H1100 or H1150 condition, as applicable.

(4) The weldment shall be liquid penetrant examined per Section VIII, Division 1, Appendix 8 after final heat treatment.

(5) The depth of weld penetration into the pressure part shall be no more than 10% of the total pressure part thickness.

(6) Separate welding procedure and performance qualification in accordance with Section IX shall be conducted.

(d) Material in the H1100 condition shall be impact tested as prescribed in UHA-51, without exemption. Material in the H1150 condition is not required to be impact tested if the MDMT is -20°F and warmer.

(e) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: This material has reduced toughness at room temperature after exposure for about 5000 hours at 600°F .

Table 1
Maximum Allowable Stress Values
for Section VIII Division 1

For Metal Temperatures, Not Exceeding, $^{\circ}\text{F}$	Allowable Stress Value, Max., ksi [Note (1)]	
	H1100 Condition	H1150 Condition
100	40.0	38.6
200	40.0	38.6
300	40.0	38.6
400	38.9	37.5
500	38.1	36.8
600	37.5	36.2

NOTE: (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.

Table 2
Maximum Design Stress Intensity Values

For Metal Temperatures Not Exceeding, $^{\circ}\text{F}$	Design Stress Intensity Value, Max., ksi
	H1150 Condition
100	45.0
200	45.0
300	45.0

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Case 2224-2

Use of 304L Stainless Steel at Elevated Temperatures

Section VIII, Division 1

Approval Date: September 18, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May Type 304L (UNS S30403) material conforming to SA-182, SA-213, SA-240, SA-249, SA-312, SA-403, SA-479, SA-965 Material Specifications be used in the construction of welded vessels designed to Section VIII, Division 1, at 850°F to 1,200°F for internal pressures not greater than 175 psi, and for nonaqueous product applications?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used for welded construction under the rules of Section VIII, Division 1 within the limits listed in the Inquiry, provided the following additional requirements are met.

(a) The allowable stresses shall be obtained from [Table 1](#).

(b) This Case number shall be identified in the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi [Notes (1)–(3)]
850	12.8 [Note (1)], 9.5
900	12.6 [Note (1)], 9.3
950	11.3 [Note (1)], 9.0
1,000	7.8, 7.8
1,050	6.3, 6.3
1,100	5.1, 5.1
1,150	4.0, 4.0
1,200	3.2, 3.2

GENERAL NOTE: Material sensitized by exposure to long-time high-temperature operation may have reduced low-temperature notch toughness.

NOTES:

- (1) Due to the relatively low yield strength of these materials, these high stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) Stress values for welded pipe and tube shall be the listed values multiplied by a factor of 0.85.
- (3) The revised criterion of 3.5 on tensile strength was used in establishing these values.

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Case 2226-2

Ni-Cr-Mo Alloy UNS N06022 for Code Construction for Temperatures up to 1250°F

Section I

Approval Date: May 21, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed nickel-chromium-molybdenum alloy UNS N06022 for the products listed in [Table 1](#) be used in welded construction under the rules of Section I up to 1,250°F?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the welded construction under the rules of Section I for temperatures up to 1,250°F provided that the following additional requirements are met.

(a) The maximum allowable stress values for the material shall be those given in [Table 2](#).

(b) The P-Number for this alloy is 43.

(c) For welded products, the allowable stresses shown in [Table 2](#) shall be multiplied by 0.85.

(d) The y values (see Section I, para. PG-27.4, Note 6) shall be as follows:

1,050°F and below	0.4
1,100°F	0.5
1,150°F	0.7
1,200°F	0.7
1,250°F	0.7

(e) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in the sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Product Specifications

Fittings	SB-366
Forgings	SB-564
Bar	SB-574
Sheet, plate, and strip	SB-575
Welded pipe	SB-619
Seamless pipe and tube	SB-622
Welded tube	SB-626

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi
-20-100	28.6, 28.6
200	28.6, 26.7
300	28.2 [Note (2)], 24.6
400	27.2 [Note (2)], 22.9
500	26.5 [Note (2)], 21.5
600	26.0 [Note (2)], 20.4
650	25.8 [Note (2)], 20.0
700	25.6 [Note (2)], 19.6
750	25.4 [Note (2)], 19.3
800	25.3 [Note (2)], 19.0
850	25.1 [Note (2)], 18.8
900	24.9 [Note (2)], 18.6
950	24.7 [Note (2)], 18.5
1,000 [Note (1)]	24.4 [Note (2)], 18.3
1,050 [Note (1)]	23.0 [Note (2)], 18.2
1,100 [Note (1)]	17.5, 17.5
1,150 [Note (1)]	12.7, 12.7
1,200 [Note (1)]	9.6, 9.6
1,250 [Note (1)]	7.6, 7.6

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Alloy N06022 in the solution annealed condition is subject to severe loss of impact properties at room temperature after exposure in the range of 1000°F to 1250°F.
- (2) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints.

Case 2230-2

Use of Ni-Al Bronze C95820 Sand Castings for Pressure Vessels

Section VIII, Division 1

Approval Date: October 29, 1999

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS C95820 sand cast tubesheets and other pressure parts meeting chemical and mechanical requirements listed in [Tables 1 and 2](#) of this Case, and otherwise conforming to all other requirements of ASTM B148-93a, be used in the construction of Section VIII, Division 1 pressure vessels?

Reply: It is the opinion of the Committee that UNS C95820 as described in the Inquiry may be used for the construction of Section VIII, Division 1 welded pressure vessels provided that the following additional requirements are met.

(a) The chemical composition and mechanical properties shall conform to the requirements of [Tables 1 and 2](#) below. The material is supplied in the as-cast condition only.

(b) The Design Temperature shall not exceed 500°F.

(c) The maximum allowable stress values shall be those listed in [Table 3](#).

(d) This material shall be considered as P-No. 35.

(e) The applicable rules of Section VIII, Division 1, Part UNF, for copper and copper alloys shall apply.

(f) The external pressure chart applicable to this material is Section VIII, Division 1, Fig. NFA-6.

(g) This Case number shall be identified in the documentation and marking of the material and shown on the Manufacturer's Data Report.

**Table 1
Chemical Requirements (UNS C95820)**

Element	Composition Limits, %
Copper, min.	77.5
Aluminum	9.0-10.0
Iron	4.0-5.0
Manganese, max.	1.5
Nickel	4.5-5.8
Silicon, max.	0.10
Lead, max.	0.02
Tin, max.	0.20

GENERAL NOTES:

- (a) Zinc shall not exceed 0.20%.
- (b) Cu + Al + Fe + Mn + Ni > 99.2%.

**Table 2
Mechanical Property Requirements**

Tensile strength, min., ksi	94.0
Yield strength, min., ksi	39.0
Elongation, in 2 in., min., %	13.0

**Table 3
Maximum Allowable Stress Values (UNS C95820)**

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, max., ksi [Note (1)]
-20-100	26.0
150	26.0
200	25.8
250	25.5
300	25.2
350	24.9
400	24.5
450	24.0
500	23.5

GENERAL NOTES:

- (a) Stress values in restricted shear shall be 0.80 times the values in this table.
- (b) Stress values in bearing shall be 1.60 times the values in this table.

NOTE: (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.

Case 2239-1

Use of Permanent Mold Cast Aluminum Alloys UNS A13560 and A03570

Section VIII, Division 1

Approval Date: October 29, 1999

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May aluminum alloys UNS A13560 and A03570 in the overaged temper meeting the chemical composition and mechanical properties given in [Tables 1](#) and [2](#) and other requirements of SB-108 be used in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that aluminum alloys UNS A13560 and A03570 as described in the above Inquiry may be used in Section VIII, Division 1 construction of pressure vessels, up to 300°F under the following conditions:

(a) The maximum allowable stress values for the materials shall be those given in [Table 3](#).

(b) Welding is not permitted.

(c) External pressure applications are not permitted.

(d) Applicable parts of Section VIII, Division 1 that shall apply are those given in Part UNF.

(e) The castings shall be heat treated. The heat treatment shall be 980°F for 8 hours, followed by a water quench, then 440°F for 7.5 hours.

(f) This Case number shall be shown on the data report and the marking of the material.

**Table 1
Chemical Composition**

UNS	Al	Si	Fe	Cu	Mn	Mg	Zn	Ti	Other Elements	
									Each	Total
A13560	Remainder	6.5-7.5	0.20	0.20	0.10	0.25-0.45	0.10	0.20	0.05	0.15
A03570	Remainder	6.5-7.5	0.15	0.05	0.03	0.45-0.65	0.05	0.20	0.05	0.15

GENERAL NOTE: When single units are shown, these amounts indicate the maximum permitted.

**Table 2
Mechanical Properties**

Temper	Tensile Strength, min., ksi	Yield Strength (0.2% Offset), min., ksi	Elongation in 2 in. or 4 Diameters, min., %	UNS
Overaged	26	19	4.0	A13560
Overaged	27	20	4.0	A03570

**Table 3
Maximum Allowable Stress Values**

Temperature, °F	ksi (A13560)	ksi (A03570)
	[Note (1)]	[Note (1)]
100	7.4	7.7
200	6.9	7.4
300	6.4	6.5

NOTE: (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.

Case 2244-2 UNS J93380 (CD3MWCuN)

Section VIII, Division 1

Approval Date: January 20, 2000

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed UNS J93380 (CD3MWCuN) casting material, with the chemical composition listed in Table 1 and the tensile properties listed in Table 2, otherwise conforming to the requirements of Specification SA-995, be used in the construction of vessels under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used under the rules of Section VIII, Division 1, provided the following additional requirements are met.

(a) The maximum allowable design stress values in tension shall be those listed in Table 3.

(b) For external pressure design, use Figure 1 and Table 4 of this Case.

(c) The material shall be considered as P-No. 10H, Group 1.

(d) Heat treatment after welding is neither required nor prohibited. However, if heat treatment is applied, the heat treatment shall consist of heating to a minimum temperature of 2010°F followed by water quenching or rapid cooling by other means.

(e) The rules that shall apply are those given in Subsection C, Part UHA for austenitic-ferritic duplex stainless steels.

(f) This Case number shall be included in the marking of the material and shown on the Manufacturer's Data Report.

**Table 1
Chemical Requirements**

Element	Composition, %
Carbon, max.	0.03
Manganese, max.	1.00
Silicon, max.	1.00
Sulfur, max.	0.025
Phosphorus, max.	0.030
Chromium	24.0–26.0
Nickel	6.5–8.5
Molybdenum	3.0–4.0
Nitrogen	0.20–0.30
Copper	0.5–1.0
Tungsten	0.5–1.0

**Table 2
Mechanical Property Requirements**

Tensile strength, min., ksi	100
Yield strength [Note (1)], min., ksi	65
Elongation in 2 in. or 50 mm	25.0

NOTE: (1) Determined by the 0.2% offset method.

**Table 3
Maximum Allowable Design Stress Values in Tension**

For Metal Temperature Not Exceeding, °F	ksi [Note (1)]
100	28.6
200	28.6
300	27.2
400	26.6
500	26.6
600	26.6

GENERAL NOTE: This material may embrittle after exposure at moderately elevated temperatures. See paras. A-340 and A-360 in Appendix A of Section II, Part D.

NOTE: (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.

Figure 1
Chart for Determining Shell Thickness of Cylindrical and Spherical Shells Under External Pressure When Constructed of High Alloy UNS S32760 And UNS J93380

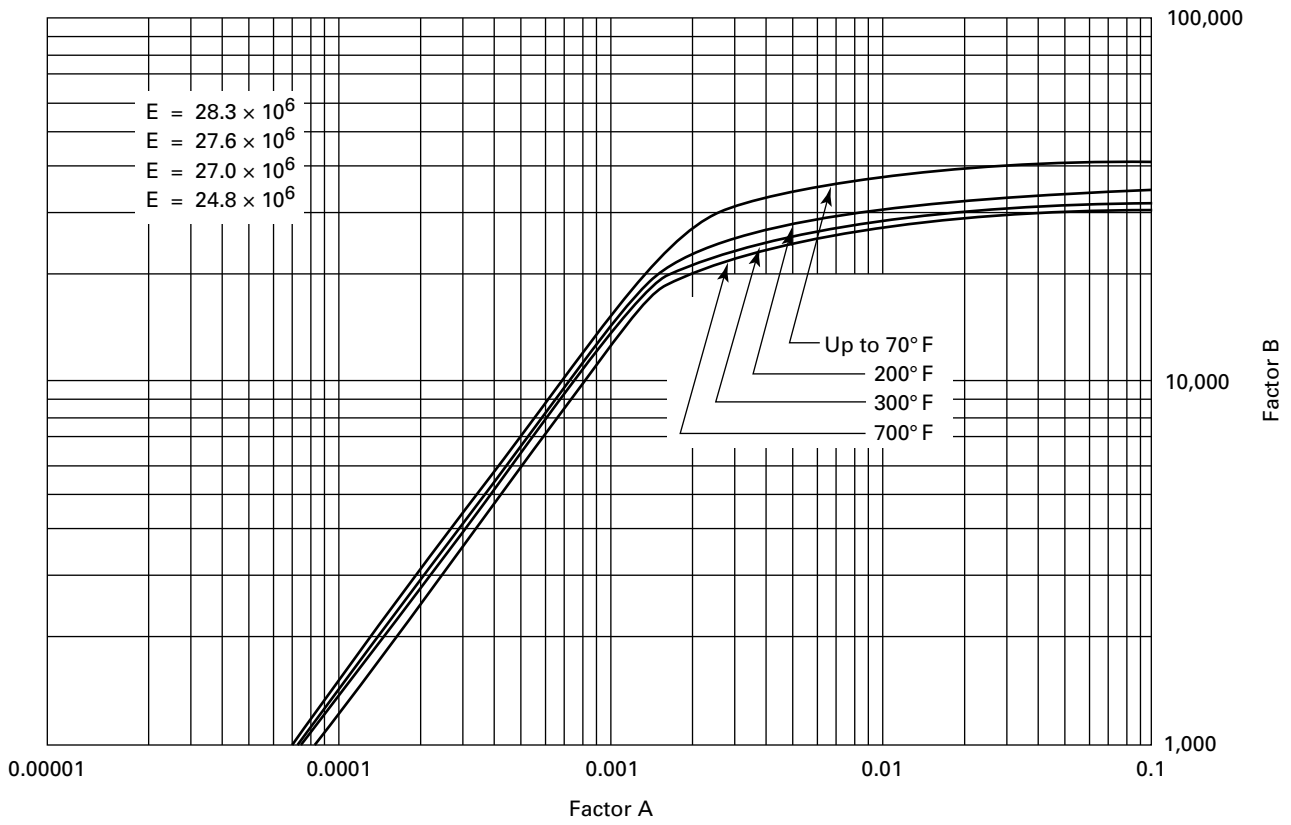


Table 4
Chart for Determining Shell Thickness of Cylindrical and Spherical Shells Under External Pressure When Constructed
of High Alloy UNS S32760 And UNS J93380

Temperature	A	B, psi	Temperature	A	B, psi
70°F	7.07E-05	1,000	300°F	7.41E-05	1,000
	0.0005	7,080		0.0005	6,750
	0.00075	10,600		0.00075	10,100
	0.000992	14,000		0.000923	12,400
	0.00121	17,100		0.00109	14,400
	0.00143	20,100		0.00128	16,500
	0.00166	23,100		0.00153	18,600
	0.00197	26,200		0.00198	20,400
	0.00284	30,100		0.00269	22,000
	0.00491	33,300		0.00392	23,600
	0.00697	34,500		0.00721	25,700
	0.00849	35,700		0.00893	26,400
	0.0192	38,700		0.019	28,700
	0.05	40,000		0.05	29,600
	0.01	40,000		0.1	29,600
200°F	7.25E-05	1,000	700°F	8.06E-05	1,000
	0.0005	6,900		0.0005	6,200
	0.00075	10,300		0.00075	9,300
	0.000939	12,900		0.000933	11,600
	0.00112	15,400		0.00108	13,400
	0.00133	17,800		0.00124	15,200
	0.00163	20,200		0.00143	17,000
	0.00194	21,500		0.00171	18,800
	0.00272	24,200		0.00277	21,700
	0.00431	26,600		0.00375	22,900
	0.00683	27,800		0.00701	24,900
	0.00872	28,800		0.00934	25,800
	0.0187	31,200		0.0192	27,700
	0.05	32,200		0.05	28,600
	0.01	32,200		0.1	28,600

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Case 2247

Alternative Pressure Test Procedure to UG-99 and UG-100 for the Construction of Multistream Aluminum Vacuum Brazed Plate-Fin Heat Exchangers

Section VIII, Division 1

Approval Date: July 9, 1998

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In Section VIII, Division 1, may an alternative pressure test procedure be implemented in the construction of multistream aluminum vacuum brazed plate-fin heat exchangers that differs from the testing requirements of UG-99 and UG-100?

Reply: It is the opinion of the Committee that multistream aluminum vacuum brazed plate-fin heat exchangers constructed to the rules of Section VIII, Division 1, may be pressure tested in accordance with the following procedure in lieu of the requirements of UG-99 and UG-100.

(a) As a minimum, the vessel shall receive two pressure tests:

- (1) first, a hydrostatic test in accordance with UG-99;
- (2) all subsequent tests are pneumatic pressure tests.

(b) The hydrostatic test shall be conducted in accordance with UG-99, including witness by the AI. All requirements of UG-99 shall be satisfied. To facilitate filling and draining of each vessel chamber (stream), vent holes shall be drilled into the header ends, as required, to purge each chamber of trapped air.

(c) Following the hydrostatic test, the vent holes shall be welded shut using procedures and welders qualified in accordance with Section IX.

(d) The exchangers are subsequently tested by a procedure employing both pneumatic and solution film leak tests to disclose leaks in the sheet to bar brazed joints

that cannot be detected by the hydrotest. The test procedure shall be as follows:

(1) Prior to application of the pneumatic and solution film leak tests the vessel shall be dried.

(2) The pneumatic fill rate is computer controlled such that the pressure is gradually increased from zero to full pressure with a fill rate decrease starting at 80% of the final pneumatic pressure. There are no intermediate stop points during the filling process. The pneumatic test pressure shall satisfy UG-100(b).

(3) The pneumatic test (pressurization cycle) shall be automatically recorded on a strip chart.

(4) The AI is afforded the option but is not required to witness either the pneumatic test or the solution film leak test.

(5) Any leaks identified in brazed joints shall be repaired using a weld repair procedure pre-accepted by the AI. The existence of any such leaks requiring repair requires a repeat of the test procedure. The AI shall be advised of the repair and afforded the option to witness the retest at his discretion.

(6) The final pneumatic test pressure charts and film leak test records shall be certified by the Manufacturer and made available to the AI for his/her review.

(e) Under Item II of the Form U-1 (Manufacturer's Data Report) for Hydrostatic or Pneumatic Test Pressure, reference shall be made to Form U-4 where the hydrostatic test pressure and all pneumatic test pressures shall be listed for each independent pressure chamber of the heat exchanger.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2249

Use of Furnace Brazing for Lethal Service

Section VIII, Division 1

Approval Date: August 11, 1997

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May vessels intended for lethal service made of nickel (UNS N02200 and/or N02201) be fabricated by vacuum furnace brazing using nickel alloy brazing filler metal?

Reply: Vessels intended for lethal service may be fabricated by brazing under the following conditions:

(a) The design temperature shall not exceed 200°F and the design pressure shall not exceed 2000 psi. The diameter of the vessel shall not exceed NPS 8, and the volume of the vessel shall not exceed 5 ft³. The size limits of brazed joint members shall be as provided below.

(b) The components to be brazed shall be nickel alloy UNS N02200 or N02201 manufactured in accordance with Specification SB-160, SB-161, SB-162, SB-163, or SB-366.

(c) The brazing process shall be vacuum furnace brazing.

(d) The brazing filler metal shall be SFA5.8, BNi-5.

(e) Use of brazing shall be limited to Category D joints and heat exchanger tube joints. The joint shall consist of a pipe or tube not greater than 2.0 in. outside diameter inserted into a socket in another member or into or through a hole in another member. The lap length [as shown in Fig. UB-16(a)] shall be not less than four times the nominal thickness of the inserted pipe or tube, except that U-tube type heat exchanger tubes shall have a lap length that is not less than 1.5 times the thickness of the inserted tube.

(f) The brazing procedure specification (BPS) shall be qualified in accordance with UB-31. In addition, a workmanship sample shall be prepared for each joint configuration and combination of material thicknesses in accordance with QB-182, except that the unbrazed length may not exceed 5% of the joint overlap. The workmanship sample shall consist of not less than six tubes inserted into the joint to the maximum depth proposed for construction. The clearance between the tube and socket in two of these joints shall be the minimum clearance proposed for construction and the clearance in two additional joints shall be the maximum proposed for construction. The minimum and maximum clearances

permitted by the BPS shall not be greater than the minimum and maximum clearances used in the workmanship samples.

(g) Prior to assembly, each joint shall be verified as having the clearance specified in the BPS. Brazing paste or preform shall be applied only to one side of any joint. Each joint shall be visually examined prior to brazing for proper application of brazing paste or external braze metal preform. These inspections shall be conducted following a written procedure which shall provide for a written record of these inspections.

(h) In order to demonstrate full penetration of the braze metal, each joint shall be visually examined after brazing on both sides of each joint. The use of inspection mirrors, boroscopes, or fiber-optic devices, as necessary, is required to accomplish this inspection where both sides of the joint are not readily viewed without optical aid. All surfaces of all joints shall be free from cracks and voids. Any assembly that exhibits cracking of either the base metal or the braze metal shall be discarded.

All joints shall show braze metal around the entire circumference of the interface between the tube and the socket on the side opposite from that on which the brazing paste or preform was applied. It is not required that the braze metal be flush with the surface or that it form a fillet. Assemblies that do not show braze metal around the entire circumference of the interface shall be discarded.

Where preforms are used, fillets at joint intersections shall not be convex on the side that the preform was placed.

These inspections shall be conducted following a written procedure that is in accordance with Section V, Article 9, and a written report of these inspections shall be prepared.

(i) Additional work may be done on brazed joints to achieve the desired surface geometry (e.g., fill concavity, increase fillet size, etc.) after they have been accepted in accordance with (h) above. This may be done by mechanical methods (e.g., grinding, machining, etc.) or by additional furnace brazing with the addition of more filler metal to either side of the joint as necessary to achieve the desired surface geometry. Rebrazing to correct surface geometry conditions shall be limited to three cycles. Modification of surface geometry by torch brazing is not permitted. All joints that have been reheated to

brazing temperature and those that are mechanically modified shall be visually examined in accordance with (h) above.

(j) After brazing and any surface geometry modifications are completed, the component shall be subjected to pressure testing in accordance with the requirements of Section VIII. After completion of pressure testing, the joints shall be subjected to a helium mass spectrometry

leak test. The testing shall be conducted in accordance with a written procedure and in accordance with the requirements and acceptance criteria of Section V, Article 10. A written record of the testing shall be prepared. Any assembly that fails the leak test shall be discarded.

(k) All other applicable rules of Section VIII shall apply.

(l) This Case number shall be shown on the Data Report Form.

Case 2254-1

Changeover Valves Installed Between Safety Valves or Safety Relief Valves and Boilers

(25)

Section I

Approval Date: April 2, 2020

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Section I, PG-71.3, requires that no valve be placed between the safety valve and boiler. Under what conditions may a changeover valve be installed between safety valves or safety relief valves and the boiler or piping to be protected?

Reply: It is the opinion of the Committee that changeover valves¹ may be installed between safety valves or safety relief valves and the boiler or piping to be protected (excluding Organic Fluid Vaporizers, Part PVG) under the following conditions.

(a) The stamped relieving capacity of the safety valve or safety relief valve shall be available whenever the boiler is in service.

(b) The changeover valve shall be designed such that there is no position where the internal plug, disc, or ball would isolate or block both safety valves or safety relief valves simultaneously.

(c) The changeover valve shall have an indicator that shows which safety valve or safety relief valve is in service. This may be accomplished by indicating which port of the changeover valve is open.

(d) The changeover valve shall have a positive locking device that permits it to be locked only when one of the outlet ports is fully open and the other outlet port is fully closed. Also, a warning tag shall be affixed to the changeover valve stating that the changeover valve is to be locked or sealed at all times except when being operated by a trained person who shall remain stationed at the changeover valve until it is again locked or sealed.

(e) The changeover valve shall be equipped with external valves to safely bleed off the pressure between the isolated safety valve or safety relief valve and the fully closed port of the changeover valve. Also,

a warning tag shall be affixed to the changeover valve stating that the bleed valve shall be fully opened prior to servicing the isolated safety valve or safety relief valve.

(f) The changeover valve shall meet the requirements for materials and design of ASME B16.34.

(g) Calculations demonstrating that the changeover valve, the mounting nozzle, and its supporting vessel or pipe are capable of sustaining reaction forces from the safety valve or safety relief valve discharge shall be made available to the Authorized Inspector.

(h) The changeover valve inlet shall be permanently and clearly marked with the word "inlet."

(i) The changeover valve shall be marked in accordance with the requirements of ASME B16.34. In addition, a nameplate shall be permanently affixed to the valve by the changeover valve manufacturer with the following information:

(1) the number of this Code Case;

(2) the actual orifice area of the safety valve or safety relief valve and coefficient of discharge K_d ;

(3) C_v value of changeover valve; and

(4) the name of the changeover valve manufacturer.

(j) The changeover valve flow path length may exceed the limit imposed by PG-71.2 provided the valve coefficient C_v meets the requirement of (k) below. The use of the Y-bases and intervening pipe or fittings as provided for in PG-71.1 and PG-71.2 respectively shall not be permitted when applying this Code Case.

(k) The changeover valve shall have a valve coefficient, C_v , equal to or greater than the following:

$$C_v = 5.69K_d K_s A \sqrt{\frac{P_r}{\delta}}$$

where

A = actual orifice area of the safety or safety relief valve (in.²)

K_d = actual coefficient of discharge of the safety or safety relief valve

K_s = superheat correction factor for the safety or safety relief valve

P_r = (1.03 × set pressure of the safety or safety relief valve) + 14.7 (psia)

¹ Changeover Valve: A three-way stop (or diverter) valve with one inlet port and two outlet ports designed to isolate either one of the two outlet ports from the inlet port, but not both simultaneously during any mode of operation.

δ = density of steam @ P_r (lb/ft³)

(l) The manufacturer of the changeover valve shall provide to the certificate holder a certified test report determining the rated C_v for the valve model, type, and size. The tests shall be made under the supervision of and certified by the manufacturer. The testing facilities, methods, and procedures shall be in accordance with the applicable requirements of ANSI/ISA-S75.02-1988.

(m) This Case number and the changeover valve name-plate information shall be shown on the Manufacturer's Data Report.

NOTE: It is recommended that the changeover valve be operated under the following conditions. Personnel trained in the operation of boilers (ASME Code Section VII) should be present during the operation of a changeover valve. Care should be taken to protect personnel from elevated temperature, excessive noise levels, and escaping fluids. It is further recommended that the boiler be operating at a reduced pressure and steady state conditions when a changeover valve is operated and also during the time any servicing is done on the safety valve or safety relief valve that is isolated from the boiler.

Case 2260-3

Alternative Rules for Design of Ellipsoidal and Torispherical Formed Heads*

Section VIII, Division 1

Approval Date: December 2, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For Section VIII, Division 1 vessels, may ellipsoidal and torispherical formed heads subjected to internal pressure be designed to rules other than those given in UG-32(c), 1-4(c) and UG-32(d), 1-4(d) respectively?

Reply: It is the opinion of the Committee that Section VIII, Division 1 vessel ellipsoidal and torispherical formed heads subjected to internal pressure may be designed using the following rules in lieu of those given in UG-32(c), 1-4(c), and UG-32(d), 1-4(d) respectively.

(a) Nomenclature

E_T = modulus of elasticity at maximum design temperature, psi. The value of E_T for all materials shall be taken from Section II, Part D, Tables TM-1, TM-2, TM-3, TM-4, or TM-5. If the maximum design temperature is greater than that shown in the above tables, then use the value of E_T corresponding to the maximum temperature given in the above tables.

E_{RT} = modulus of elasticity at 70°F, psi. The value of modulus of elasticity for all materials shall be taken from Section II, Part D, Tables TM-1, TM-2, TM-3, TM-4, or TM-5.

h = one-half of the length of the inside minor axis of the ellipsoidal head, or the inside depth of the ellipsoidal head measured from the tangent line (head-bend line), in.

$D/2h$ = ratio of the major to the minor axis of ellipsoidal heads, which equals the inside diameter of the head skirt divided by twice the inside height of the head.

See UG-32(b) for other nomenclature.

(b) *Torispherical Heads.* The minimum required thickness of a torispherical head having $0.002 \leq t/L \leq 0.06$ shall be larger of the thicknesses calculated by eq. (1) and eq. (2) below.

$$t = \frac{PLM}{2SE - 0.2P} \quad (1)$$

$$t = \frac{3PLKE_{RT}}{4S_a E_T} \quad (2)$$

The value of S_a shall be 115,000 psi for all ferrous and nonferrous materials except for aluminum, aluminum alloys, copper, copper alloys, titanium and zirconium, for which the value of S_a shall be calculated by eq. (3).

$$S_a = \frac{115,000 \times E_{RT}}{30 \times 10^6} \quad (3)$$

The value of M shall be obtained from Table 1. Interpolation may be used for r/D values which fall within the range of the tabulated values. No extrapolation of the values is permitted.

The value of K shall be obtained from Table 2. Interpolation may be used for r/D values which fall within the range of the tabulated values. No extrapolation of the values is permitted.

For designs where $t/L > 0.06$, the rules of UG-32(e) or 1-3 shall be used. In 1-3 equations (1) and (2), R shall be replaced with L .

(c) *Ellipsoidal Heads.* The minimum required thickness of an ellipsoidal head with $D/2h$ ratio less than or equal to 2.0 shall be established as an equivalent torispherical head using the rules given in (b) above. An acceptable approximation of a 2:1 ellipsoidal head is one with a knuckle radius of $0.17D$ and a spherical radius of $0.9D$.

(d) The requirement of UHT-32 does not apply.

(e) Size of the finished openings in the knuckle area shall not exceed the lesser of $2^3/8$ in. or $0.5r$. For an ellipsoidal head, the knuckle area is the area located outside a circle whose center coincides with the center of the head and whose diameter is equal to 80% of the head inside diameter.

* Corrected by errata, ASME BPVC.CC.BPV.S7-2019, December 2020

(f) This Case has been developed for fatigue life of 400 full pressure range cycles with nonintegral attachments and 1000 full pressure range cycles with integral attachments. See U-2(g) for design of heads exceeding the above fatigue life.

(g) The rules of this Code Case may result in relatively high local strains in the knuckle. The effect of these high strains in areas where structural attachments are located shall be considered. See U-2(g).

(h) This Case shall not be used for Part UCI and Part UCD heads.

(i) The maximum design temperature shall not exceed the maximum temperature limit specified in Table 3.

(j) All other applicable Code requirements including those of UG-32 shall be met.

(k) This Case number shall be shown on the Manufacturer's Data Report.

Table 1

t/L	M for $r/D = 0.06$	M for $r/D = 0.07$	M for $r/D = 0.08$	M for $0.08 < r/D \leq 0.2$
0.002	1.00	1.00	1.00	1.00
0.004	1.00	1.00	1.00	1.00
0.006	1.28	1.00	1.00	1.00
0.008	1.41	1.20	1.00	1.00
0.010	1.41	1.26	1.10	1.00
0.012	1.38	1.25	1.13	1.00
0.016	1.31	1.21	1.12	1.00
0.020	1.25	1.17	1.08	1.00
0.030	1.14	1.08	1.01	1.00
0.040	1.07	1.01	1.00	1.00
0.060	1.00	1.00	1.00	1.00

Table 2

t/L	K for $r/D = 0.06$	K for $r/D = 0.08$	K for $r/D = 0.10$	K for $r/D = 0.14$	K for $r/D = 0.17$	K for $r/D = 0.20$
0.002	7.87	6.29	5.24	3.95	3.31	2.81
0.004	6.77	5.60	4.69	3.49	2.93	2.50
0.006	6.04	5.14	4.38	3.27	2.73	2.33
0.008	5.51	4.78	4.14	3.13	2.60	2.21
0.010	5.11	4.49	3.93	3.02	2.51	2.13
0.012	4.79	4.25	3.76	2.93	2.44	2.06
0.016	4.31	3.87	3.47	2.77	2.33	1.97
0.020	3.96	3.58	3.24	2.63	2.24	1.91
0.030	3.48	3.10	2.84	2.37	2.07	1.79
0.040	3.32	2.97	2.69	2.23	1.95	1.72
0.060	3.12	2.80	2.56	2.17	1.92	1.71

Table 3
Maximum Metal Temperature

Table in Which Material is Listed	Temperature, °F
UCS-23	700
UNF-23.1	300
UNF-23.2	150
UNF-23.3	900
UNF-23.4	600
UNF-23.5	600
UHA-23	800
UHT-23	700

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Case 2276-1

Austenitic Ni-Cr-Mo-Nb Alloy (UNS N06626)

Section VIII, Division 1

Approval Date: February 17, 2000

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May austenitic Ni-Cr-Mo-Nb alloy (UNS N06626), up to and including 0.100 in. in thickness, wrought sheet and strip, welded pipes, welded tubes, and welded fittings with the chemical analysis shown in [Table 1](#), the minimum mechanical properties shown in [Table 2](#), and the grain size requirements shown in [Table 3](#) be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section VIII, Division 1 construction up to a design temperature of 800°F, provided the following additional requirements are met.

(a) The rules in Section VIII, Division 1 that shall apply are those given in Part UNF for nickel alloys.

(b) The maximum allowable stress values for the material shall be those given in [Table 4](#). For welded pipes, tubes, and fittings, a joint efficiency factor of 0.85 shall be used.

(c) Material shall conform to all other requirements of SB-443, SB-704, SB-705, and SB-366, as applicable.

(d) Material shall be considered as P-No. 43.

(e) Heat treatment after forming or fabrication is neither required nor prohibited. However, if heat treatment is conducted, the resulting material must still comply with the requirements of [Tables 2](#) and [3](#).

(f) The applicable external pressure chart shall be Fig. NFN-17 in Section II, Part D.

(g) This Case number shall be shown on the Manufacturer's Data Report.

**Table 1
Chemical Requirements**

Element	Composition Limits, %
Nickel [Note (1)]	Remainder
Chromium	20.0–23.0
Molybdenum	8.0–10.0
Niobium	3.15–4.15
Iron	5.0 max.
Carbon	0.03 max.
Silicon	0.15 max.
Nitrogen	0.02 max.
Manganese	0.50 max.
Sulfur	0.015 max.
Aluminum	0.40 max.
Titanium	0.40 max.
Phosphorus	0.015 max.
Cobalt	1.0 max.

NOTE: (1) This element shall be determined arithmetically by difference.

**Table 2
Mechanical Property Requirements (Room Temperature)**

Tensile strength, min., ksi	120
Yield strength, 0.2% offset min., ksi	60
Elongation in 2 in. gage or 4D min., %	40

**Table 3
ASTM Grain Size No. Requirements**

Up to 0.010 in., incl.	8 or finer
0.010 to 0.050 in., incl.	6 or finer
0.050 to 0.100 in., incl.	5 or finer

**Table 4
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi [Note (1)]
100	34.3
200	34.3
300	33.9, 34.3 [Note (2)]
400	32.6, 34.3 [Note (2)]
500	31.7, 34.3 [Note (2)]
600	31.1, 34.3 [Note (2)]
650	30.8, 34.3 [Note (2)]
700	30.5, 34.3 [Note (2)]
750	30.3, 34.3 [Note (2)]
800	30.1, 34.1 [Note (2)]

NOTES:

- (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Case 2286-6

Alternative Rules for Determining Allowable External Pressure and Compressive Stresses for Cylinders, Cones, Spheres, and Formed Heads

Section VIII, Division 1

Approval Date: October 30, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May alternative rules for determining allowable external pressure and compressive stresses for cylinders, cones, spheres, and formed heads be used for the design of these components in lieu of the rules of Section VIII, Division 1, UG-23, UG-28, UG-29, UG-33, and Appendix 1-8?

Reply:

(a) It is the opinion of the Committee that cylinders, cones, spheres, and formed heads for pressure vessels otherwise designed and constructed in accordance with the rules of Section VIII, Division 1, may be designed using the following rules for calculation of allowable external pressure and compressive stresses in lieu of the rules stated in the Inquiry above.

(b) When used, this Case shall be made applicable to the entire vessel.

(c) This Case number shall be shown on the Manufacturer's Data Report.

1 SCOPE, DESIGN, METHOD, AND NOMENCLATURE

1.1 SCOPE

This Case provides alternative rules to those given in Section VIII, Division 1, UG-23(b), UG-28, UG-29, UG-33 and Appendix 1-8 for determining allowable compressive stresses for unstiffened and ring stiffened circular cylinders and cones, and for unstiffened spherical, ellipsoidal, and torispherical heads. The allowable stress equations are based upon theoretical buckling equations that have been reduced by knockdown factors and by plasticity reduction factors that were determined from tests on fabricated shells. (Nomenclature is provided in 1.4.)

This Case expands the coverage of load conditions and shell geometries, and includes equations for combinations of loads not considered in the Code paragraphs referenced

above. These alternative rules are applicable to D_o/t ratios not exceeding 2,000, compared to the $D_o/t = 1,000$ limit is Fig. G in Subpart 3 of Section II, Part D. The slenderness limit for these rules in $KL_u/r \leq 200$. Use of these alternative rules assumes the shell section to be axisymmetric with uniform thickness for unstiffened cylinders and formed heads. Stiffened cylinders and cones are also assumed to be of uniform thickness between stiffeners. Where nozzles with reinforcing plates or locally thickened shell sections exist, use the thinnest uniform thickness in the applicable unstiffened or stiffened shell section for calculation of allowable compressive stress.

The maximum temperature permitted for use of this Case is shown in Table 1.

Alternative equations for determination of allowable compressive stress due to loads specified in UG-22 are provided. A listing of the allowable stress cases, combinations of cases, requirements for tolerances, and reinforcement of openings by Case paragraph number is given in Table 2, with indication of present coverage in Division 1.

1.2 BUCKLING DESIGN METHOD

The buckling strength formulations presented in this Case are based on classical linear theory with simple support boundary conditions and Poisson's ratio of 0.3. The differences between elastic stresses obtained for buckling tests on fabricated shells and the theoretical

Table 1

Table in Which Material is Listed, Division 1	Max. Temperature, °F
UCS-23.1	800
UNF-23.1	300
UNF-23.2	150
UNF-23.3	900
UNF-23.4	600
UNF-23.5	600
UHA-23	800
UHT-23	700

Table 2

Para. No.	Subject	Covered in Div. 1
3	Allowable Compressive Stresses for cylindrical shells	Yes, in part
3.1	External Pressure	Yes
3.2	Uniform axial compression	Yes
3.2.1	Local buckling	Yes
3.2.2	Column buckling	No
3.3	Axial compression due to bending	No
3.4	Shear	No
4	Allowable Compressive Stresses for Cones	Yes, in part
4.1	External pressure	Yes
4.1.1	Allowable Circumferential Compression Stresses	Yes
4.1.2	Intermediate Stiffener Rings	No
4.1.3	Cone-Cylinder Junction Rings	Yes
4.2	Uniform Axial Compression and Bending	Yes, in part
4.2.1	Allowable Longitudinal and Bending Stresses	Yes
4.2.2	Unstiffened Cone-Cylinder Junctions	Yes
4.2.3	Cone-Cylinder Junction Rings	Yes
4.3	Shear	No
4.4	Local Stiffener Geometry Requirements	No
5	Allowable Stress Equations for Unstiffened and Ring Stiffened Cylinders and Cones Under Combined Loads	No
5.1	Combination of Uniform Axial Compression & Hoop Compression	No
5.2	Combination of Axial Compression Due to Bending Moment, M, and Hoop Compression	No
5.3	Combination of Hoop Compression and Shear	No
5.4	Combination of Uniform Axial Compression, Axial Compression Due to Bending Moment, M, and Shear in the Presence of Hoop Compression	No
5.5	Combination of Uniform Axial Compression, Axial Compression Due to Bending Moment, M, and Shear in the Absence of Hoop Compression	No
6	Sizing of Rings (General Instability)	Yes, in part
6.1	External pressure	Yes, but only (b)
6.2	Uniform Axial Compression and Axial Compression — Bending	No
6.3	Shear	No
6.4	Local Stiffener Geometry Requirements	No
7	Tolerances for Cylindrical & Conical Shells	Yes, in part
7.1	Shells Subjected to Internal Pressure	Yes, in part
7.2	Shells Subjected to Uniform Axial Compression and Axial Compression Due to Bending Moment	No
7.3	If Tolerances are Exceeded, Allowable Buckling Stress Adjustment	No
7.4	Measurements for Deviation	Yes, in part
7.5	Shells Subjected to Shear	Yes
8	Allowable Compressive Stresses for Spherical Shells and Formed Heads, with Pressure on Convex Side	Yes, in part
8.1.1	Spherical Shells with Equal Biaxial Stresses	Yes
8.1.2	Spherical Shells with Unequal Biaxial Stresses, both Compressive	No
8.1.3	Spherical Shells with Unequal Biaxial, one stress compressive and the other tensile	No
8.1.4	Shear	No
8.2	Toroidal and Ellipsoidal Heads	Yes, in part
8.3	Tolerances for Formed Heads	Yes, in part
9	Reinforcement for Openings	Yes, in part

buckling stresses are accounted for by knockdown factors. These factors are equivalent to the ratio of strain in a fabricated shell at buckling stress and the strain corresponding to the theoretical buckling stress. The design equations apply to shells with initial imperfections within the specified fabrication tolerances of 7 and 8.3.

The design of cylinders and cones for compressive loads is an iterative procedure. The first step in the design process is to assume a shell geometry and thickness and calculate the resulting stresses from dead and live (including pressure) loads. The next step is to calculate the allowable stresses for individual load cases and substitute these values into interaction equations for combined load cases. The shell thickness or geometry can be adjusted to give the desired agreement between applied and allowable stresses.

The next step is to determine the stiffener sizes if rings are used. The stiffener elements must satisfy the requirements of 6.4 to prevent local buckling of the stiffener.

Special consideration shall be given to ends of members (shell sections) or areas of load application where stress distribution may be in the inelastic range and localized stresses may exceed those predicted by linear theory. When the localized stresses extend over a distance equal to one half the length of a buckle node (approximately $1.2\sqrt{D_0t}$), the localized stresses should be considered as a uniform stress around the full circumference. Additional stiffening may be required.

1.3 GEOMETRY

Allowable stress equations are given for the following geometries:

- (a) Unstiffened cylindrical, conical, and spherical shells
- (b) Ring stiffened cylindrical and conical shells
- (c) Unstiffened spherical, ellipsoidal, and torispherical heads

The cylinder and cone geometries are illustrated in Figures 1.4.1 and 1.4.3 and the stiffener geometries in Figure 1.4.4. The effective sections for ring stiffeners are shown in Figure 1.4.2. The maximum cone angle α shall not exceed 60 deg.

1.4 NOMENCLATURE

NOTE: The terms not defined here are uniquely defined in the sections in which they are first used. The word "hoop" used in this Case is synonymous with the term "circumferential."

- A = cross-sectional area of cylinder
= $\pi(D_0 - t)t$, in.²
- A_F = cross-sectional area of a large ring stiffener that acts as a bulkhead, in.²
- A_S = cross-sectional area of a ring stiffener, in.²
- c = distance from neutral axis of cross-section to point under consideration, in.

D_e = outside diameter of assumed equivalent cylinder for design of cones or conical sections, in.

D_i = inside diameter of cylinder, in.

D_L = outside diameter at large end of cone, or conical section between lines of support, in.

D_o = outside diameter of cylinder, in.

D_S = outside diameter at small end of cone, or conical section between lines of support, in.

E = modulus of elasticity of material at design temperature, determined from the applicable material chart in Subpart 2 of Section II, Part D, ksi. The applicable material chart is given in Tables 1A and 1B, Subpart 1, Section II, Part D. Use linear interpolation for intermediate temperatures.

E_t = tangent modulus, ksi

f_a = axial (longitudinal) compressive membrane stress resulting from applied axial load, Q , ksi

F_{aha} = allowable axial compressive membrane stress of a cylinder due to axial compression load in the presence of hoop compression with $\lambda_c > 0.15$, ksi

f_b = axial (longitudinal) compressive membrane stress resulting from applied bending moment, M , ksi

F_{ba} = allowable axial compressive membrane stress of a cylinder due to bending moment, M , in the absence of other loads, ksi

F_{bha} = allowable axial compressive membrane stress of a cylinder due to bending in the presence of hoop compression, ksi

F_{ca} = allowable compressive membrane stress of a cylinder due to axial compression load with $\lambda_c > 0.15$, ksi

F_{cha} = allowable axial compressive membrane stress of a cylinder due to axial compression load in the presence of hoop compression for $0.15 < \lambda_c < 1.2$, ksi. $F_{cha} = F_{aha}$ when $f_q = 0$.

f_h = hoop compressive membrane stress resulting from applied external pressure, P , ksi

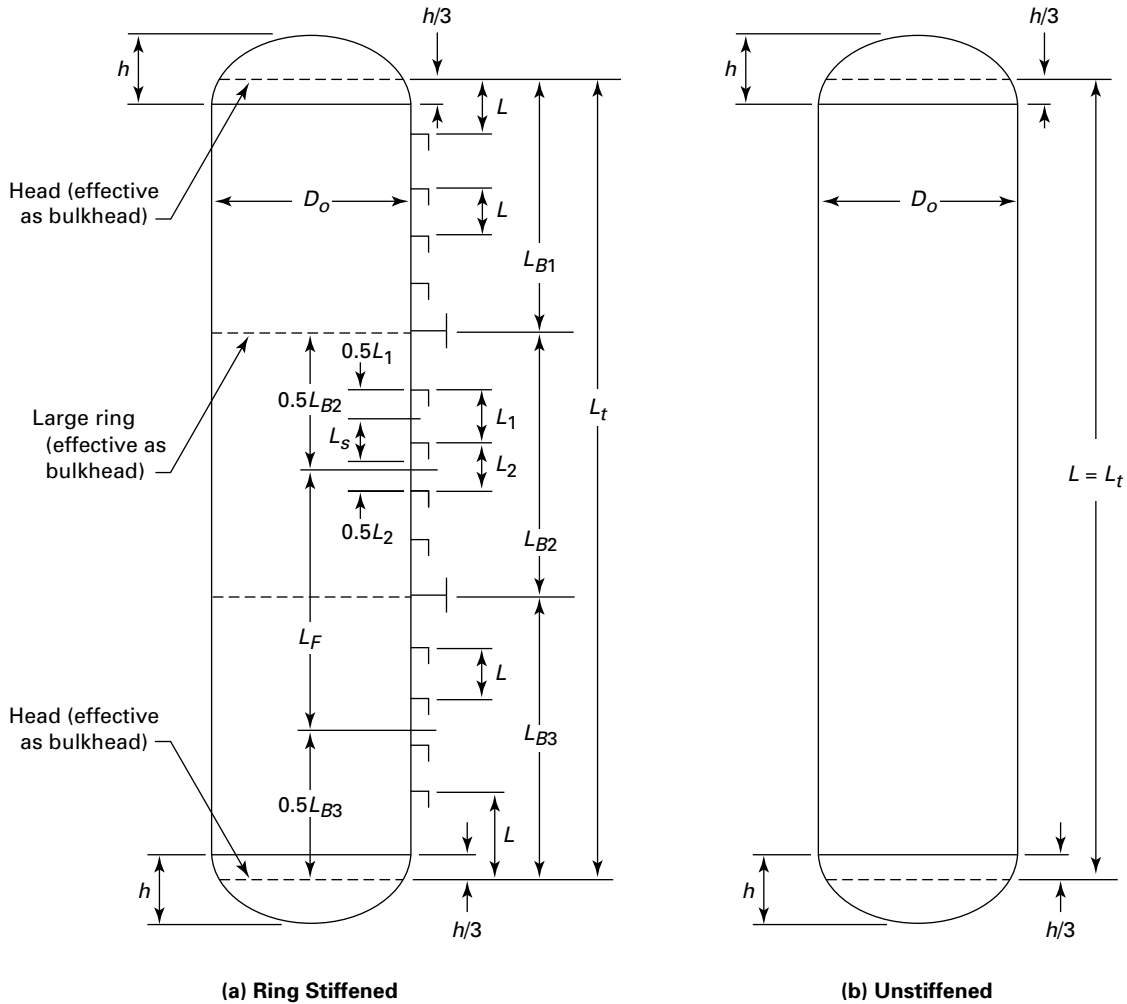
F_{ha} = allowable hoop compressive membrane stress of a cylinder or formed head under external pressure alone, ksi

F_{hba} = allowable hoop compressive membrane stress of a cylinder in the presence of longitudinal compression due to a bending moment, ksi

F_{he} = elastic hoop compressive membrane failure stress of a cylinder or formed head under external pressure alone, ksi

F_{hva} = allowable hoop compressive membrane stress in the presence of shear stress, ksi

**Figure 1.4.1
Geometry of Cylinders**



- F_{hxa} = allowable hoop compressive membrane stress of a cylinder in the presence of axial compression, for $\lambda_c \leq 0.15$, ksi
- f_q = axial (longitudinal) compressive membrane stress resulting from pressure load, Q_p , on end of cylinder, ksi
- F_{ta} = allowable stress in tension, from applicable table in Subpart 1 of Section II, Part D, ksi
- f_v = shear stress from applied loads, ksi
- F_{va} = allowable shear stress of a cylinder subjected only to shear stress, ksi
- F_{ve} = elastic shear buckling stress of a cylinder subjected only to shear stress, ksi
- F_{vha} = allowable shear stress of a cylinder subjected to shear stress in the presence of hoop compression, ksi
- $f_x = f_a + f_q$, ksi

- F_{xa} = allowable compressive membrane stress of a cylinder due to axial compression load with $\lambda_c \leq 0.15$, ksi
- F_{xe} = elastic axial compressive membrane failure (local buckling) stress of a cylinder in the absence of other loads, ksi
- F_{xha} = allowable axial compressive membrane stress of a cylinder in the presence of hoop compression for $\lambda_c \leq 0.15$, ksi.
- F_y = yield strength of material at design metal temperature from applicable table in Subpart 1 of Section II, Part D, ksi. For values of F_y not provided in Section II, Part D, use UG-28(c)(2), Steps (3)(a) and (3)(b).
- FS = stress reduction factor or design factor
- I_s = moment of inertia of ring stiffener about its centroidal axis, in.⁴

Figure 1.4.2
Sections Through Rings

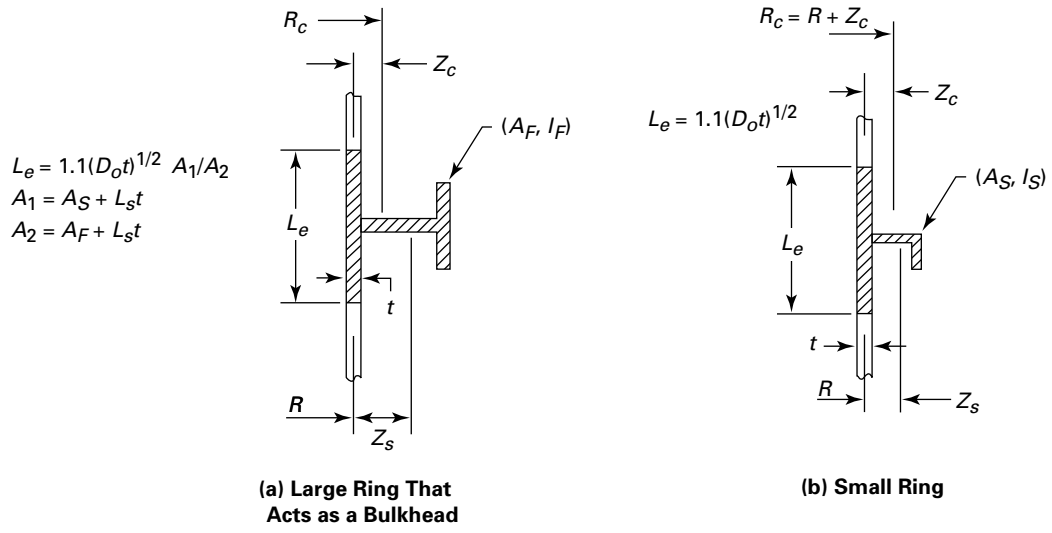


Figure 1.4.3
Geometry of Conical Sections

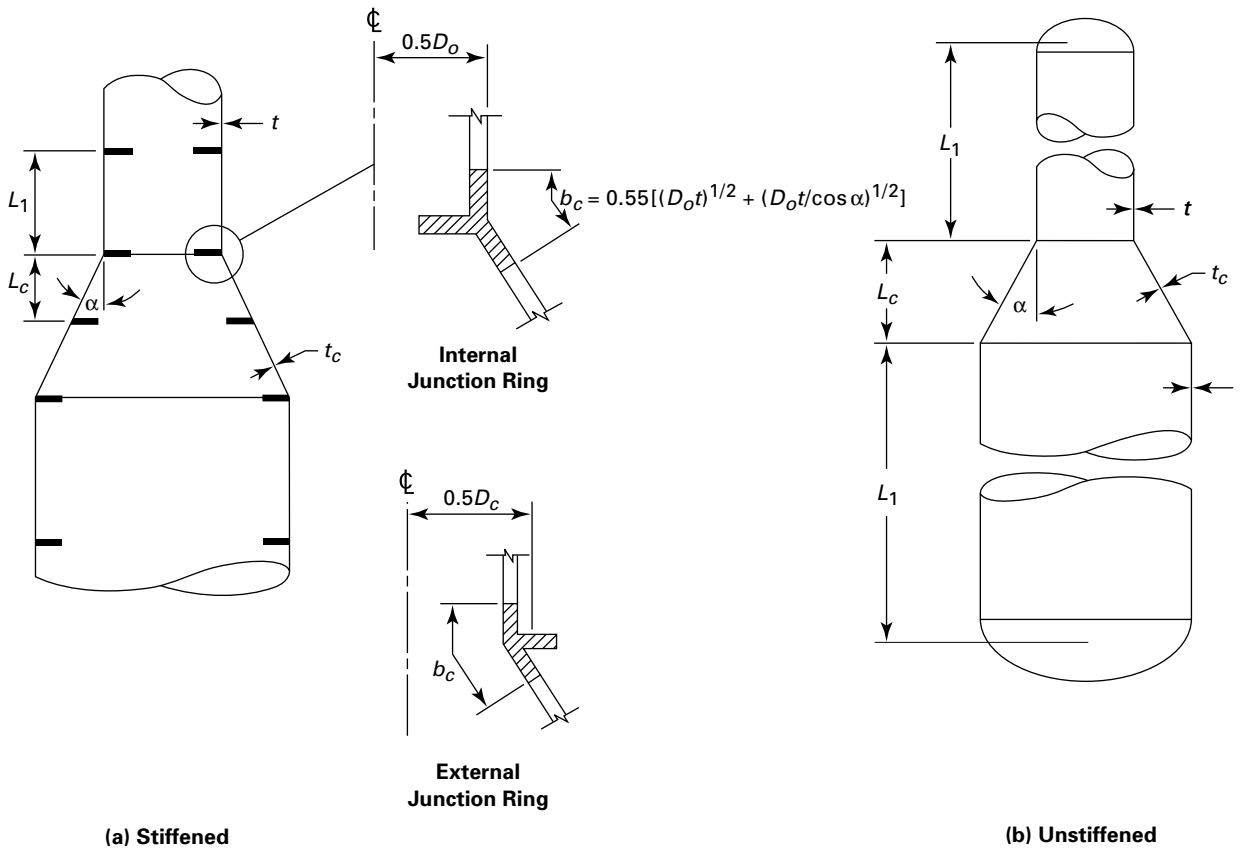
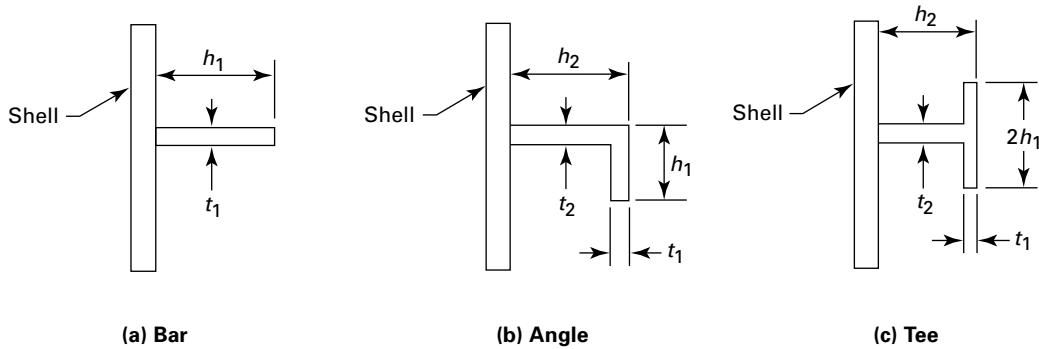


Figure 1.4.4
Stiffener Geometry for Eqs. 6.4(a)(6-6) and 6.4(b)(6-7)



I'_s = moment of inertia of ring stiffener plus effective length of shell about centroidal axis of combined section, in.⁴

$$I'_s = I_s + A_s Z_s^2 \frac{L_e t}{A_s + L_e t} + \frac{L_e t^3}{12}$$

I = moment of inertia of full cross-section,

$$I = \pi R^3 t, \text{ in.}^4$$

K = effective length factor for column buckling; refer to 3.2 for further definition

$L_B, L_{B1},$

$L_{B2}, L_{B...}$ = length of cylinder between bulkheads or large rings designed to act as bulkheads, in.

L_c = axial length of cone or conical section, in. (see Figure 1.4.3)

L_e = effective length of shell, in. (see Figure 1.4.2)

L_F = one-half of the sum of the distances, L_B , from the centerline of a large ring to the next large ring or head line of support on either side of the large ring, in. (see Figure 1.4.1)

L_s = one-half of the sum of the distances from the center line of a stiffening ring to the next line of support on either side of the ring, measured parallel to the axis of the cylinder, in. A line of support is described in the definition for L (see Figure 1.4.1), in.

L_t = overall length of vessel as shown in Figure 1.4.1, in.

L_u = laterally unbraced (laterally unsupported) length of a cylindrical member that is subject to column buckling, in. This applies to supports for pressure vessels or pedestal type vessels. Stiffening rings are not points of support unless they are externally supported. (Refer also to addi-

tional explanation at the end of this nomenclature section.)

$L, L_1,$

$L_2, L...$ = design length of unstiffened vessel section between lines of support or the total length of tube between tube sheets, in. A line of support is:

(a) a circumferential line on a head (excluding conical heads) at one-third the depth of the head from the head tangent line as shown on Figure 1.4.1

(b) a stiffening ring that meets the requirements of eq. 6.1(a)(6-1)

(c) a tubesheet

M = applied bending moment across the vessel cross-section, in.-kips

$$M_s = L_s / \sqrt{R_o t}$$

$$M_x = L / \sqrt{R_o t}$$

P = applied external pressure, ksi

P_a = allowable external pressure in the absence of other loads, ksi

Q = applied axial compression load, kips

Q_p = axial compression load on end of cylinder resulting from applied external pressure, kips

R = radius to centerline of shell, in.

r = radius of gyration of cylinder, in.

$$r = \frac{(D_o^2 + D_i^2)^{1/2}}{4}$$

R_c = radius to centroid of combined ring stiffener and effective length of shell, in.

$$R_c = R + Z_c$$

R_o = radius to outside of shell, in.

S = elastic section modulus of full shell cross-section, in.³

$$S = \frac{\pi(D_o^4 - D_i^4)}{32D_o}$$

t = thickness of shell, less corrosion allowance, in.

t_c = thickness of cone, less corrosion allowance, in.

V = shear force from applied loads at cross-section under consideration, kips

Z_c = radial distance from centerline of shell to centroid of combined section of ring and effective length of shell, in.

$$Z_c = \frac{A_s Z_s}{A_s + L_e t}$$

Z_s = radial distance from centerline of shell to centroid of ring stiffener (positive for outside rings), in.

α = one-half of the apex angle of a conical section

β = capacity reduction factor to account for shape imperfections

λ_c = slenderness factor for column buckling

$$\lambda_c = \frac{KL_u}{\pi r} \sqrt{\frac{F_{xa} FS}{E}}$$

Φ = angle measured around the circumference from the direction of applied shear force to the point under consideration

In the equation for λ_c above, a laterally unsupported length, L_u , for a free-standing pressure vessel without guide wires or other bracing should be measured from the top head tangent line to the base of the vessel support skirt. For λ_c values ≤ 0.15 , consideration for column instability (column buckling) is not required for either the vessel shell or the vessel skirt for any of the load combinations in 5. For $\lambda_c > 0.15$, consideration for column buckling is required, see 5 and specifically 5.1.2.

For load combinations including external pressure, the load on the end of a cylinder due to external pressure does not contribute to instability of the pressure vessel as a free standing column (column buckling). The axial compressive stress due to external pressure load does, however, lower the effective yield stress of the pressure shell [see eq. 5.1.2(5-3)], and the quantity in the parentheses $(1 - f_q/F_y)$ accounts for this reduction. The reduced effective yield stress does not apply to parts that are not part of the pressure shell.

2 GENERAL DESIGN INFORMATION

2.1 MATERIALS

The allowable stress equations apply directly to shells fabricated from carbon and low alloy steel materials listed in Table UCS-23 of Section VIII at temperatures below the creep range. These equations can also be applied to other materials for which a chart or table is provided in Subpart 3 of Section II, Part D. The method for calculating the allowable stresses for shells constructed from these materials is determined by the following procedure.

Step 1. Calculate the value of factor A using the following equations. The terms F_{xe} , F_{he} , and F_{ve} are defined in the Nomenclature (1.4).

$$A = \frac{F_{xe}}{E} \quad A = \frac{F_{he}}{E} \quad A = \frac{F_{ve}}{E}$$

Step 2. Using the value of A calculated in Step 1, enter the applicable material chart in Subpart 3 of Section II, Part D for the material under consideration. Move vertically to an intersection with the material temperature line for the design temperature. Use interpolation for intermediate temperature values.

Step 3. From the intersection obtained in Step 2, move horizontally to the right to obtain the value of B . E_t is given by the following equation:

$$E_t = \frac{2B}{A}$$

When values of A fall to the left of the applicable material/temperature line in Step 2, $E_t = E$.

Step 4. Calculate the allowable stresses from the following equations:

$$F_{xa} = \frac{F_{xe} E_t}{FS E} \quad F_{ba} = F_{xa} \quad F_{ha} = \frac{F_{he} E_t}{FS E} \quad F_{va} = \frac{F_{ve} E_t}{FS E}$$

2.2 STRESS REDUCTION FACTORS

Allowable stresses in this Case for design and test conditions are determined by applying a stress reduction factor, FS , to predicted buckling stresses calculated in this Case. The required values of FS are 2.0 when the buckling stress is elastic and 1.67 when the buckling stress equals yield stress at design temperature. A linear variation shall be used between these limits. The equations for FS are given below.

$$\begin{aligned} FS &= 2.0 && \text{if } F_{ic} \leq 0.55F_y \\ FS &= 2.407 - 0.741F_{ic}/F_y && \text{if } 0.55F_y < F_{ic} < F_y \\ FS &= 1.667 && \text{if } F_{ic} \geq F_y \end{aligned}$$

F_{ic} is the predicted buckling stress, which is determined by letting $FS = 1$ in the allowable stress equations. For combinations of earthquake loading or wind loading with other load cases listed in UG-22, the allowable stresses may be increased as permitted by UG-23(c).

2.3 CAPACITY REDUCTION FACTORS (β)

Capacity reduction factors that account for shape imperfections are built into the allowable stress equations in this Case. These factors are in addition to the stress reduction factors in 2.2.

(a) For unstiffened or ring stiffened cylinders under axial compression:

$$\beta = 0.207 \quad \text{for} \quad \frac{D_o}{t} \geq 1,247$$

$$\beta = \frac{338}{389 + \frac{D_o}{t}} \quad \text{for} \quad \frac{D_o}{t} < 1,247$$

(b) Unstiffened and ring stiffened cylinders and cones under external pressure: $\beta = 0.8$

(c) Spherical, torispherical, and ellipsoidal heads under external pressure: $\beta = 0.124$

2.4 STRESS COMPONENTS FOR STABILITY ANALYSIS AND DESIGN

Stress components that control the buckling of a cylindrical shell consist of longitudinal, circumferential, and in-plane shear membrane stresses.

3 ALLOWABLE COMPRESSIVE STRESSES FOR CYLINDRICAL SHELLS

The maximum allowable stresses for cylindrical shells subjected to loads that produce compressive stresses are given by the following equations. For stress components acting alone, the maximum values shall be used. For combined stress components, the concurrent (coexisting) stress values shall be used.

In no case shall the allowable primary membrane compressive stresses exceed the maximum allowable tensile stress listed in Section II, Part D.

3.1 EXTERNAL PRESSURE

The allowable circumferential compressive stress for a cylinder under external pressure is given by F_{ha} and the allowable external pressure is given by the following equation.

$$P_a = 2F_{ha} \frac{t}{D_o}$$

$$F_{ha} = \frac{F_y}{FS} \quad \text{for} \quad \frac{F_{he}}{F_y} \geq 2.439 \quad (3-1a)$$

$$F_{ha} = \frac{0.7F_y \left(\frac{F_{he}}{F_y} \right)^{0.4}}{FS} \quad \text{for} \quad 0.552 < \frac{F_{he}}{F_y} < 2.439 \quad (3-1b)$$

$$F_{ha} = \frac{F_{he}}{FS} \quad \text{for} \quad \frac{F_{he}}{F_y} \leq 0.552 \quad (3-1c)$$

where

$$F_{he} = 1.6C_h E \frac{t}{D_o} \quad (3-2)$$

$$C_h = 0.55 \frac{t}{D_o} \quad \text{for} \quad M_x \geq 2 \left(\frac{D_o}{t} \right)^{0.94} \quad (3-2a)$$

$$C_h = 1.12M_x^{-1.058} \quad \text{for} \quad 13 < M_x < 2 \left(\frac{D_o}{t} \right)^{0.94} \quad (3-2b)$$

$$C_h = \frac{0.92}{M_x - 0.579} \quad \text{for} \quad 1.5 < M_x \leq 13 \quad (3-2c)$$

$$C_h = 1.0 \quad \text{for} \quad M_x \leq 1.5 \quad (3-2d)$$

3.2 UNIFORM AXIAL COMPRESSION

Allowable longitudinal stress for a cylindrical shell under uniform axial compression is given by F_{xa} for values of $\lambda_c \leq 0.15$ and by F_{ca} for values of $\lambda_c > 0.15$.

$$\lambda_c = \frac{KL_u}{\pi r} \sqrt{\frac{F_{xa} FS}{E}}$$

where KL_u is the effective length. L_u is the unbraced length. Minimum values for K are:

(a) 2.1 for members with one end free and the other end fixed (i.e., "free standing" pressure vessels supported at grade)

(b) 1.0 for members with both ends pinned

(c) 0.8 for members with one end pinned and the other end fixed

(d) 0.65 for members with both ends fixed

In this case, “member” is the unbraced cylindrical shell or cylindrical shell section as defined in the Nomenclature, 1.4.

3.2.1 LOCAL BUCKLING (FOR $\lambda_c \leq 0.15$).

F_{xa} is the smaller of the values given by eqs. (3-3a) through (3-3c) and (3-4).

$$F_{xa} = \frac{F_y}{FS} \quad \text{for} \quad \frac{D_o}{t} \leq 135 \quad (3-3a)$$

$$F_{xa} = \frac{466F_y}{\left(331 + \frac{D_o}{t}\right)FS} \quad \text{for} \quad 135 < \frac{D_o}{t} < 600 \quad (3-3b)$$

$$F_{xa} = \frac{0.5F_y}{FS} \quad \text{for} \quad \frac{D_o}{t} \geq 600 \quad (3-3c)$$

or

$$F_{xa} = \frac{F_{xe}}{FS} \quad (3-4)$$

where

$$F_{xe} = \frac{C_x Et}{D_o} \quad (3-5)$$

$$C_x = \frac{409\bar{c}}{389 + \frac{D_o}{t}} \quad \text{not to exceed } 0.9 \quad \text{for} \quad \frac{D_o}{t} < 1247$$

$$C_x = 0.25\bar{c} \quad \text{for} \quad \frac{D_o}{t} \geq 1247$$

$$\bar{c} = 2.64 \quad \text{for} \quad M_x \leq 1.5$$

$$\bar{c} = \frac{3.13}{M_x^{0.42}} \quad \text{for} \quad 1.5 < M_x < 15$$

$$\bar{c} = 1.0 \quad \text{for} \quad M_x \geq 15$$

$$M_x = \frac{L}{(R_o t)^{1/2}} \quad (3-6)$$

3.2.2 Column Buckling ($\lambda_c > 0.15$ and $KL_u/r < 200$).

$$F_{ca} = F_{xa} [1 - 0.74(\lambda_c - 0.15)]^{0.3} \quad (3-7a)$$

for $0.15 < \lambda_c < 1.2$

$$F_{ca} = \frac{0.88F_{xa}}{\lambda_c^2} \quad \text{for} \quad \lambda_c \geq 1.2 \quad (3-7b)$$

3.3 AXIAL COMPRESSION DUE TO BENDING MOMENT

Allowable longitudinal stress for a cylinder subjected to a bending moment acting across the full circular cross-section is given by F_{ba} .

$$F_{ba} = F_{xa} \quad (\text{see } 3.2.1) \quad \text{for} \quad \frac{D_o}{t} \geq 135 \quad (3-8a)$$

$$F_{ba} = \frac{466F_y}{FS \left(331 + \frac{D_o}{t}\right)} \quad \text{for} \quad 100 \leq \frac{D_o}{t} < 135 \quad (3-8b)$$

$$F_{ba} = \frac{1.081F_y}{FS} \quad \text{for} \quad \frac{D_o}{t} < 100 \quad \text{and} \quad \gamma \geq 0.11 \quad (3-8c)$$

$$F_{ba} = \frac{(1.4 - 2.9\gamma)F_y}{FS} \quad \text{for} \quad \frac{D_o}{t} < 100 \quad \text{and} \quad \gamma < 0.11 \quad (3-8d)$$

where

$$\gamma = \frac{F_y D_o}{Et} \quad (3-8e)$$

3.4 SHEAR

Allowable in-plane shear stress for a cylindrical shell is given by F_{va} .

$$F_{va} = \frac{\eta_v F_{ve}}{FS} \quad (3-9)$$

where

$$F_{ve} = \alpha_v C_v E \frac{t}{D_o} \quad (3-10)$$

$$C_v = 4.454 \quad \text{for} \quad M_x \leq 1.5 \quad (3-11a)$$

$$C_v = \left(\frac{9.64}{M_x^2}\right) \left(1 + 0.0239M_x^3\right)^{1/2} \quad \text{for} \quad 1.5 < M_x < 26 \quad (3-11b)$$

$$C_v = \frac{1.492}{M_x^{1/2}} \quad \text{for} \quad 26 \leq M_x < 4.347 \frac{D_o}{t} \quad (3-11c)$$

$$C_v = 0.716 \left(\frac{t}{D_o} \right)^{1/2} \quad \text{for } M_x \geq 4.347 \frac{D_o}{t} \quad (3-11d)$$

$$\alpha_v = 0.8 \quad \text{for } \frac{D_o}{t} \leq 500 \quad (3-11e)$$

$$\alpha_v = 1.389 - 0.218 \log_{10} \left(\frac{D_o}{t} \right) \quad \text{for } \frac{D_o}{t} > 500 \quad (3-11f)$$

$$\eta_v = 1.0 \quad \text{for } \frac{F_{ve}}{F_y} \leq 0.48 \quad (3-11g)$$

$$\eta_v = 0.43 \frac{F_y}{F_{ve}} + 0.1 \quad \text{for } 0.48 < \frac{F_{ve}}{F_y} < 1.7 \quad (3-11h)$$

$$\eta_v = 0.6 \frac{F_y}{F_{ve}} \quad \text{for } \frac{F_{ve}}{F_y} \geq 1.7 \quad (3-11i)$$

4 ALLOWABLE COMPRESSIVE STRESSES FOR CONES

Unstiffened conical transitions or cone sections between rings of stiffened cones with an angle $\alpha \leq 60$ deg shall be designed for local buckling as an equivalent cylinder according to the following procedure. See [Figure 1.4.3](#) for cone geometry.

4.1 EXTERNAL PRESSURE

4.1.1 Allowable Circumferential Compression Stresses. Assume an equivalent cylinder with diameter, D_e , equal to $0.5(D_L + D_S)/\cos \alpha$, $L_{ce} = L_c/\cos \alpha$. The value D_e is substituted for D_o , L_{ce} for L , and $D_e/2$ for R_o in the equations given in [3.1](#) to determine F_{ha} . The allowable stress must be satisfied at all cross-sections along the length of the cone.

4.1.2 Intermediate Stiffening Rings. If required, circumferential stiffening rings within cone transitions shall be sized using [eq. 6.1\(a\)\(6-1\)](#).

4.1.3 Cone-Cylinder Junction Rings. A junction ring is not required for buckling due to external pressure if $f_h < F_{ha}$ where F_{ha} is determined from [eqs. 3.1\(3-1a\)](#) through [3.1\(3-1c\)](#) with F_{he} computed using C_h equal to $0.55(\cos \alpha)(t/D_o)$ in [eq. 3.1\(3-2\)](#). D_o is the cylinder diameter at the junction. The hoop stress may be calculated from the following equation.

$$f_h = \frac{P D_o}{2 t_c \cos \alpha}$$

If $t_c \cos \alpha$ is less than t , then substitute t for t_c to determine C_h and f_h .

Circumferential stiffening rings required at the cone-cylinder junctions shall be sized such that the moment of inertia of the composite ring section satisfies the following equation:

$$I_c \geq \frac{D^2}{16E} \left\{ t L_1 F_{he} + \frac{t_c L_c F_{hec}}{\cos^2 \alpha} \right\} \quad (4-1)$$

where

D = cylinder outside diameter at junction

F_{he} = elastic hoop buckling stress for cylinder [see [eq. 3.1\(3-2\)](#)]

$F_{hec} = F_{he}$ for cone section treated as an equivalent cylinder

L_1 = distance to first stiffening ring in cylinder section or line of support

L_c = distance to first stiffening ring in cone section along cone axis as shown in [Figure 1.4.3](#)

t = cylinder thickness

t_c = cone thickness

4.2 UNIFORM AXIAL COMPRESSION AND BENDING

4.2.1 Allowable Longitudinal and Bending Stresses.

Assume an equivalent cylinder with diameter D_e equal to $D/\cos \alpha$, where D is the outside diameter at the cross-section under consideration and length equal to L_c . D_e is substituted for D_o in the equations given in [3.2](#) and [3.3](#) to find F_{xa} and F_{ba} and L_c for L in [eq. 3.2.1\(3-6\)](#). The radius R_o is equal to $D_e/2$ at the large end of the cone. The allowable stress must be satisfied at all cross-sections along the length of the cone.

4.2.2 Unstiffened Cone-Cylinder Junctions. Cone-cylinder junctions are subject to unbalanced radial forces (due to axial load and bending moment) and to localized bending stresses caused by the angle change. The longitudinal and hoop stresses at the junction may be evaluated as follows:

(a) *Longitudinal Stress.* In lieu of detailed analysis, the localized bending stress at an unstiffened cone-cylinder junction may be estimated by the following equation.

$$f'_b = \frac{0.6t\sqrt{D(t+t_c)}}{t_c^2} (f_x + f_b) \tan \alpha \quad (4-2)$$

where

D = outside diameter of cylinder at junction to cone
 f_b = longitudinal stress in cylinder section at the cone-cylinder junction resulting from bending moment
 f_x = uniform longitudinal stress in cylinder section at the cone-cylinder junction resulting from pressure and/or applied axial loads, see Nomenclature, 1.4
 t = thickness of cylinder
 t_c = thickness of cone
 $t_e = t_c$ to find stress in cone section
 $t_e = t$ to find stress in cylinder section
 α = cone angle as defined in Figure 1.4.3

For strength requirements, the total stress ($f_x + f_b + f'_b$) in the cone and cylinder sections shall be limited to 3 times the allowable stress at temperature listed in Section II, Part D, Tables 1A and 1B. The combined stress ($f_x + f_b$) shall not exceed the allowable stress at temperature listed in Section II, Part D, Tables 1A and 1B.

(b) *Hoop Stress.* The hoop stress caused by the unbalanced radial line load may be estimated from:

$$f'_h = 0.45\sqrt{D/t}(f_x + f_b)\tan\alpha \quad (4-3)$$

For hoop tension, f'_h shall be limited to 1.5 times the tensile allowable per (a) above. The applicable joint efficiency shall be included when determining the allowable tensile stress. For hoop compression, f'_h shall be limited to F_{ha} where F_{ha} is computed from eqs. 3.1(3-1a) through 3.1(3-1c) with

$$F_{he} = 0.4E(t/D)$$

A cone-cylinder junction that does not satisfy the above criteria may be strengthened either by increasing the cylinder and cone wall thickness at the junction, or by providing a stiffening ring at the junction.

4.2.3 Cone-Cylinder Junction Rings. If stiffening rings are required, the section properties shall satisfy the following requirements:

$$A_c \geq \frac{tD}{F_y}(f_x + f_b)\tan\alpha \quad (4-4)$$

$$I_c \geq \frac{tD(D_c)^2}{8E}(f_x + f_b)\tan\alpha \quad (4-5)$$

where

A_c = cross-sectional area of composite ring section
 D = cylinder outside diameter at junction = D_L or D_s in Fig. UG-33.1

D_c = diameter to centroid of composite ring section for external rings
 = D_i for internal rings
 I_c = moment of inertia of composite ring section

In computing A_c and I_c , the effective length of shell wall acting as a flange for the composite ring section shall be computed from:

$$b_e = 0.55(\sqrt{Dt} + \sqrt{Dt_c/\cos\alpha}) \quad (4-6)$$

The nearest surface of the stiffening ring shall be located within a distance of t_r or 1 in., whichever is greater, from the cone junction. The thickness of the ring, t_r , is defined by t_1 or t_2 in Figure 1.4.4.

4.3 SHEAR

4.3.1 Allowable In-Plane Shear Stress. Assume an equivalent cylinder with a length equal to the slant length between rings ($L_c/\cos\alpha$) and a diameter D_e equal to $D/\cos\alpha$, where D is the outside diameter of the cone at the cross-section under consideration. This length and diameter shall be substituted into the equations given in 3.4 to determine F_{va} .

4.3.2 Intermediate Stiffening Rings. If required, circumferential stiffening rings within cone transition shall be sized using eq. 6.4(a)(6-6) where L_s is the average distance to adjacent rings along the cone axis.

4.4 LOCAL STIFFENER GEOMETRY REQUIREMENTS

To preclude local buckling of a stiffener, the requirements of 6.4 must be met.

4.5 TOLERANCES

The tolerances specified in 7 shall be met.

5 ALLOWABLE STRESS EQUATIONS FOR UNSTIFFENED AND RING-STIFFENED CYLINDERS AND CONES UNDER COMBINED LOADS

The following rules do not apply to cylinders and cones under load combinations that include external pressure for values of $\lambda_c \geq 1.2$. For $\lambda_c \geq 1.2$, this Case is not applicable.

For load combinations that include uniform axial compression, the longitudinal stress to use in the interaction equations is f_x for local buckling equations ($\lambda_c \leq 0.15$) and f_a for column buckling equations ($\lambda_c > 0.15$). The stress component, f_q , which results from pressure on the ends of the cylinder, does not contribute to column buckling.

5.1 FOR COMBINATION OF UNIFORM AXIAL COMPRESSION AND HOOP COMPRESSION

5.1.1 For $\lambda_c \leq 0.15$ the allowable stress in the longitudinal direction is given by F_{xha} and the allowable stress in the circumferential direction is given by F_{hxa} .

$$f_x \leq F_{xha}$$

$$F_{xha} = \left(\frac{1}{F_{xa}^2} - \frac{C_1}{C_2 F_{xa} F_{ha}} + \frac{1}{C_2^2 F_{ha}^2} \right)^{-0.5} \quad (5-1)$$

where

$$C_1 = \frac{(F_{xa} FS + F_{ha} FS)}{F_y} - 1.0 \quad (5-1a)$$

and

$$C_2 = \frac{f_x}{f_h} \quad (5-1b)$$

$$f_x = f_a + f_q = \frac{Q}{A} + \frac{Q_p}{A} \quad \text{and} \quad f_h = \frac{PD_o}{2t}$$

Equation (5-1) should not be used (does not apply) if either f_h is not present (or not being considered), or $f_x = 0$. F_{xa} FS is given by the smaller of eqs. 3.2.1(3-3a) through 3.2.1(3-3c) or eq. 3.2.1(3-4), and F_{ha} FS is given by eqs. 3.1(3-1a) through 3.1(3-1c). To determine F_{xa} and F_{ha} the values of FS are obtained from 2.2.

$$F_{hxa} = \frac{F_{xha}}{C_2} \quad (5-2)$$

The values of FS are to be determined independently for the axial and hoop directions.

5.1.2 For $0.15 < \lambda_c < 1.2$, the allowable stress in the longitudinal direction is given by F_{aha} , and is determined from column buckling considerations. (The rules do not apply to values of $\lambda_c \geq 1.2$ for shells under combined axial compression and external pressure.)

$$f_a \leq F_{aha} \quad \text{where} \quad F_{aha} = F_{cha} \left(1 - \frac{f_q}{F_y} \right) \quad (5-3)$$

The load on the end of a cylinder due to external pressure does not contribute to column buckling and therefore F_{aha} is compared with f_a rather than f_x . The stress due to the pressure load does, however, lower the effective yield stress and the quantity in parentheses $(1 - f_q/F_y)$ accounts for this reduction. F_{cha} is obtained from eqs. 3.2.2(3-7a) and 3.2.2(3-7b) by substituting F_{xha} ,

determined from eq. 5.1.1(5-1) for F_{xa} . The resulting equations are:

$$F_{cha} = F_{xha} \quad \text{for} \quad \lambda_c \leq 0.15 \quad (5-3a)$$

$$F_{cha} = F_{xha} [1 - 0.74(\lambda - 0.15)]^{0.3} \quad \text{for} \quad 0.15 < \lambda_c < 1.2 \quad (5-3b)$$

5.2 FOR COMBINATION OF AXIAL COMPRESSION DUE TO BENDING MOMENT, M, AND HOOP COMPRESSION

The allowable stress in the longitudinal direction is given by F_{bha} , and the allowable stress in the circumferential direction is given by F_{hba} .

$$F_b \leq F_{bha}$$

$$F_{bha} = C_3 C_4 F_{ba} \quad (5-4)$$

where C_3 and C_4 are given by the following equations and F_{ba} is given by eqs. 3.3(3-8a) through 3.3(3-8e).

$$C_4 = \frac{f_b F_{ha}}{f_h F_{ba}} \quad (5-4a)$$

$$C_3^2 (C_4^2 + 0.6C_4) + C_3^{2n} - 1 = 0 \quad (5-5)$$

$$f_b = \frac{Mc}{I} \quad \text{and} \quad f_h = \frac{PD_o}{2t} \quad \text{and} \quad n = 5 - 4 \frac{F_{ha} \cdot FS}{F_y}$$

Solve for C_3 from eq. (5-5) by iteration. F_{ha} is given by eq. 3.1(3-1a).

$$F_{hba} = F_{bha} \frac{f_h}{f_b} \quad (5-6)$$

5.3 FOR COMBINATION OF HOOP COMPRESSION AND SHEAR

The allowable shear stress is given by F_{vha} and the allowable circumferential stress is given by F_{hva} .

$$F_{vha} = \left[\left(\frac{F_{va}^2}{2C_5 F_{ha}} \right)^2 + F_{va}^2 \right]^{1/2} - \frac{F_{va}^2}{2C_5 F_{ha}} \quad (5-7)$$

where

$$C_5 = \frac{f_v}{f_h}$$

$$f_v = V \sin \phi / \pi R t$$

F_{va} is given by eq. 3.4(3-9) and F_{ha} is given by eq. 3.1(3-1a).

$$F_{hva} = \frac{F_{vha}}{C_5} \quad (5-8)$$

5.4 FOR COMBINATION OF UNIFORM AXIAL COMPRESSION, AXIAL COMPRESSION DUE TO BENDING MOMENT, M , AND SHEAR, IN THE PRESENCE OF HOOP COMPRESSION ($f_h \neq 0$)

$$\text{Let } K_s = 1 - \left(\frac{f_v}{F_{va}} \right)^2 \quad (5-9)$$

5.4.1 For $\lambda_c \leq 0.15$

$$\left(\frac{f_a}{K_s F_{xha}} \right)^{1.7} + \frac{f_b}{K_s F_{bha}} \leq 1.0 \quad (5-10)$$

F_{xha} is given by eq. 5.1.1(5-1), F_{bha} is given by eq. 5.2(5-4) and F_{va} is given by eq. 3.4(3-9).

5.4.2 For $0.15 < \lambda_c < 1.2$

$$\frac{f_a}{K_s F_{aha}} + \frac{8}{9} \frac{\Delta f_b}{K_s F_{bha}} \leq 1.0 \quad (5-11)$$

$$\text{for } \frac{f_a}{K_s F_{aha}} \geq 0.2 \quad (5-12)$$

$$\frac{f_a}{2K_s F_{aha}} + \frac{\Delta f_b}{K_s F_{bha}} \leq 1.0 \quad \text{for } \frac{f_a}{K_s F_{aha}} < 0.2$$

where

$$\Delta = \frac{C_m}{1 - \frac{f_a FS}{F_e}} \quad (5-12a)$$

$$F_e = \frac{\pi^2 E}{(KL_u/r)^2} \quad (5-12b)$$

See 5.1 for F_{xha} . F_{bha} is given by eq. 5.2(5-4). K is the effective length factor (see 3.2). FS is determined from equations in 2.2, where $F_{ic} = F_{xa} FS$ [see eqs. 3.2.1(3-3a) and 3.2.1(3-4)].

C_m = coefficient whose value shall be taken as follows:

(a) For compression members in frames subject to joint translation (side sway),

$$C_m = 0.85$$

(b) For rotationally restrained compression members in frames braced against joint translation and not subject to transverse loading between their supports in the plane of bending,

$$C_m = 0.6 - 0.4(M_1/M_2)$$

where M_1/M_2 is the ratio of the smaller to larger moments at the ends of that portion of the member unbraced in the plane of bending under consideration. M_1/M_2 is positive when the member is bent in reverse curvature and negative when bent in single curvature.

(c) For compression members in frames braced against joint translation and subjected to transverse loading between their supports:

(1) for members whose ends are restrained against rotation in the plane of bending,

$$C_m = 0.85$$

(2) for members whose ends are unrestrained against rotation in the plane of bending, for example, an unbraced skirt supported vessel,

$$C_m = 1.0$$

5.5 FOR COMBINATION OF UNIFORM AXIAL COMPRESSION, AXIAL COMPRESSION DUE TO BENDING MOMENT, M , AND SHEAR, IN THE ABSENCE OF HOOP COMPRESSION ($f_h = 0$)

5.5.1 For $\lambda_c \leq 0.15$

$$\left(\frac{f_a}{K_s F_{xa}} \right)^{1.7} + \frac{f_b}{K_s F_{ba}} \leq 1.0 \quad (5-13)$$

F_{xa} is given by the smaller of eqs. 3.2.1(3-3a) through 3.2.1(3-3c) or eq. 3.2.1(3-4), F_{ba} is given by eqs. 3.3(3-8a) through 3.3(3-8e) and K_s is given by eq. 5.4(5-9).

5.5.2 For $0.15 < \lambda_c < 1.2$

$$\frac{f_a}{K_s F_{ca}} + \frac{8}{9} \frac{\Delta f_b}{K_s F_{ba}} \leq 1.0 \quad \text{for } \frac{f_a}{K_s F_{ca}} \geq 0.2 \quad (5-14)$$

$$\frac{f_a}{2K_s F_{ca}} + \frac{\Delta f_b}{K_s F_{ba}} \leq 1.0 \quad \text{for } \frac{f_a}{K_s F_{ca}} < 0.2 \quad (5-15)$$

F_{ca} is given by eqs. 3.2.2(3-7a) through 3.2.2(3-7b), F_{ba} is given by eqs. 3.3(3-8a) through 3.3(3-8e), and K_s is given by eq. 5.4(5-9). See 5.4.2 for definition of Δ .

6 SIZING OF RINGS (GENERAL INSTABILITY)

6.1 EXTERNAL PRESSURE

(a) Small rings

$$I'_s \geq \frac{1.5 F_{he} L_s R_c^2 t}{E(n^2 - 1)} \quad (6-1)$$

where

F_{he} = stress determined from eq. 3.1(3-2) with $M_x = M_s$

$$n^2 = \frac{2D_o^{3/2}}{3L_B t^{1/2}}$$

$$n = 2 \quad \text{for } n^2 \leq 4$$

$$= 10 \quad \text{for } n^2 > 100$$

(b) Large rings that act as bulkheads

$$I'_s \geq I_F \quad (6-2)$$

$$I_F = \frac{F_{heF} L_F R_c^2 t}{2E} \quad (6-2a)$$

where

F_{heF} = average value of the hoop buckling stresses, F_{he} , over length L_F where F_{he} is determined from eq. 3.1(3-2), ksi

I_F = the value of I'_s , which makes a large stiffener act as a bulkhead. The effective length of shell is

$$L_e = 1.1 \sqrt{D_o t} (A_1/A_2)$$

A_1 = cross-sectional area of small ring plus shell area equal to $L_s t$, in.²

A_2 = cross-sectional area of large ring plus shell area equal to $L_s t$, in.²

R_c = radius to centroid of combined large ring and effective width of shell, in.

6.2 UNIFORM AXIAL COMPRESSION AND AXIAL COMPRESSION DUE TO BENDING

When ring stiffeners are used to increase the allowable longitudinal compressive stress, the following equations must be satisfied. For a stiffener to be considered, M_x shall be less than 15.

$$A_s \geq \left[\frac{0.334}{M_s^{0.6}} - 0.063 \right] L_s t \quad \text{and} \quad A_s \geq 0.06 L_s t \quad (6-3)$$

$$\text{also } I'_s \geq \frac{5.33 L_s t^3}{M_s^{1.8}} \quad (6-4)$$

6.3 SHEAR

$$I'_s \geq 0.184 C_v M_s^{0.8} t^3 L_s \quad (6-5)$$

where

C_v = value determined from eqs. 3.4(3-11a) through 3.4(3-11i) with $M_x = M_s$.

6.4 LOCAL STIFFENER GEOMETRY REQUIREMENTS

Stiffener geometry requirements are as follows. See Figure 1.4.4 for stiffener geometry and definition of terms.

(a) Flat bar stiffener, flange of a tee stiffener, and outstanding leg of an angle stiffener

$$\frac{h_1}{t_1} \leq 0.375 \left(\frac{E}{F_y} \right)^{1/2} \quad (6-6)$$

where h_1 is the full width of a flat bar stiffener or outstanding leg of an angle stiffener and one-half of the full width of the flange of a tee stiffener and t_1 is the thickness of the bar, leg of angle, or flange of tee.

(b) Web of tee stiffener or leg of angle stiffener attached to shell

$$\frac{h_2}{t_2} \leq 1.0 \left(\frac{E}{F_y} \right)^{1/2} \quad (6-7)$$

where h_2 is the full depth of a tee section or full width of an angle leg and t_2 is the thickness of the web or angle leg.

7 TOLERANCES FOR CYLINDRICAL AND CONICAL SHELLS

7.1 SHELLS SUBJECTED TO EXTERNAL PRESSURE

Cylindrical and conical shells shall meet the tolerances as specified herein. These tolerance requirements replace some portions of those specified in UG-80(b). All requirements of UG-80(a) are applicable. In place of the maximum deviation requirements specified in UG-80(b)(2), the following requirements apply.

The maximum deviation from a true circular form, e , shall not exceed the value given by the following equations.

$$e = 0.0165t(M_x + 3.25)^{1.069} \quad (7-1)$$

e need not be less than $0.2t$, and shall not exceed the smaller of $0.0242R$ or $2t$.

7.2 SHELLS SUBJECTED TO UNIFORM AXIAL COMPRESSION AND AXIAL COMPRESSION DUE TO BENDING MOMENT

Cylindrical and conical shells shall meet the out-of-roundness limitations specified in UG-80(a). Additionally, the local deviation from a straight line, e , measured along a meridian over a gauge length L_x shall not exceed the maximum permissible deviation e_x given below.

$$\begin{aligned} e_x &= 0.002R \\ L_x &= 4\sqrt{Rt} \text{ but not greater than } L \text{ for cylinders} \\ &= 4\sqrt{Rt/\cos\alpha} \text{ but not greater than } L_c/\cos\alpha \text{ for cones} \\ &= 25t \text{ across circumferential welds} \end{aligned}$$

Also L_x is not greater than 95% of the meridional distance between circumferential welds.

7.3 IF TOLERANCES ARE EXCEEDED, ALLOWABLE BUCKLING STRESS ADJUSTMENT

The maximum deviation, e , can exceed e_x if the maximum axial stress is less than F_{xa} for shells designed for axial compression only or less than F_{xha} for shells designed for combinations of axial compression and external pressure. The change in buckling stress is given in eq. (7-2), and the reduced allowable buckling stress, $F_{xe(\text{reduced})}$, is determined as shown by eq. (7-3a) using the values for F_{xa} and FS_{xa} from eqs. 3.2.1(3-3a) through 3.2.1(3-3c) and eq. 3.2.1(3-4).

$$F'_{xe} = \left[0.944 - 0.286 \log \left(\frac{e}{e_x} 0.0005 \right) \right] E \frac{t}{R} \quad (7-2)$$

where e is the new maximum deviation. The quantity

$$0.286 \log \left(\frac{e}{e_x} 0.0005 \right)$$

is an absolute number (i.e., the log of a very small number is negative). See example for $e = 2e_x$ below.

For example, when $e = 2e_x$, the reduction in allowable buckling stress can be calculated by the following formula:

$$F'_{xe} = 0.086E \frac{t}{R} \quad (7-3)$$

$$\text{Then } F_{xa(\text{reduced})} = \frac{F_{xa} * FS_{xa} - F'_{xe}}{FS_{xa}} \quad (7-3a)$$

7.4 MEASUREMENTS FOR DEVIATIONS

Measurements to determine e shall be made from a segmental circular template having the design outside radius, and placed on outside of the shell. The chord length L_c is given by the following equation

$$L_c = 2R \sin(\pi/2n) \quad (7-4)$$

$$n = c \left(\frac{\sqrt{R/t}}{L/R} \right)^d \text{ and } 2 \leq n \leq 1.41(R/t)^{0.5} \quad (7-5)$$

where

$$\begin{aligned} c &= 2.28(R/t)^{0.54} \leq 2.80 \\ d &= 0.38(R/t)^{0.44} \leq 0.485 \end{aligned}$$

The requirements of UG-80(b)(3), (4), (6), (7), (8), and UG-80(b)(10) remain applicable.

7.5 SHELLS SUBJECTED TO SHEAR

Cylindrical and conical shells shall meet the tolerances specified in UG-80(a).

8 ALLOWABLE COMPRESSIVE STRESSES FOR SPHERICAL SHELLS AND FORMED HEADS, WITH PRESSURE ON CONVEX SIDE

8.1 SPHERICAL SHELLS

8.1.1 With Equal Biaxial Stresses. The allowable compressive stress for a spherical shell under uniform external pressure is given by F_{ha} and the allowable external pressure is given by P_a .

$$F_{ha} = \frac{F_y}{FS} \text{ for } \frac{F_{he}}{F_y} \geq 6.25 \quad (8-1a)$$

Table 3
Factor K_o

Use Interpolation for Intermediate Values						
$D_o/2h_o$	...	3.0	2.8	2.6	2.4	2.2
K_o	...	1.36	1.27	1.18	1.08	0.99
$D_o/2h_o$	2.0	1.8	1.6	1.4	1.2	1.0
K_o	0.90	0.81	0.73	0.65	0.57	0.50

$$F_{ha} = \frac{1.31F_y}{FS \left(1.15 + \frac{F_y}{F_{he}}\right)} \quad \text{for } 1.6 < \frac{F_{he}}{F_y} < 6.25 \quad (8-1b)$$

$$F_{ha} = \frac{0.18F_{he} + 0.45F_y}{FS} \quad \text{for } 0.55 < \frac{F_{he}}{F_y} \leq 1.6 \quad (8-1c)$$

$$F_{ha} = \frac{F_{he}}{FS} \quad \text{for } \frac{F_{he}}{F_y} \leq 0.55 \quad (8-1d)$$

$$F_{he} = 0.075E \frac{t}{R_o} \quad (8-2)$$

$$P_a = 2F_{ha} \frac{t}{R_o} \quad (8-3)$$

unequal biaxial stresses σ_1 and σ_2 , where σ_1 is a compression stress and σ_2 is a tensile stress, is given by F_{1a} .

F_{1a} is the value of F_{ha} determined from eqs. 8.1.1(8-1a) through 8.1.1(8-1d) With F_{he} given by eq. (8-6).

$$F_{he} = (C_o + C_p)E \frac{t}{R_o} \quad (8-6)$$

$$C_o = \frac{102.2}{195 + R_o/t} \quad \text{for } \frac{R_o}{t} < 622 \quad (8-6a)$$

$$C_o = 0.125 \quad \text{for } \frac{R_o}{t} \geq 622 \quad (8-6b)$$

$$C_p = \frac{1.06}{3.24 + \frac{1}{\bar{p}}}, \quad \bar{p} = \frac{\sigma^2 R_o}{E t} \quad (8-6c)$$

where R_o is the radius to the outside of the spherical shell and F_{ha} is given by eqs. (8-1a) through (8-1d).

8.1.2 With Unequal Biaxial Stresses — Both Stresses Are Compressive. The allowable compressive stresses for a spherical shell subjected to unequal biaxial stresses, σ_1 and σ_2 , where both σ_1 and σ_2 are compression stresses resulting from applied loads, are given by the following equations.

$$F_{1a} = \frac{0.6}{1 - 0.4k} F_{ha} \quad (8-4)$$

$$F_{2a} = kF_{1a} \quad (8-5)$$

where $k = \sigma_2/\sigma_1$ and F_{ha} is given by eqs. 8.1.1(8-1a) through 8.1.1(8-1d). F_{1a} is the allowable stress in the direction of σ_1 and F_{2a} is the allowable stress in the direction of σ_2 . σ_1 is the larger of the compression stresses.

8.1.3 With Unequal Biaxial Stresses — One Stress Is Compressive and the Other Is Tensile. The allowable compressive stress for a spherical shell subjected to

8.1.4 Shear. When shear is present, the principal stresses shall be calculated and used for σ_1 and σ_2 .

8.2 TOROIDAL AND ELLIPSOIDAL HEADS

The allowable compressive stresses for formed heads is determined by the equations given for spherical shells where R_o is defined below.

h_o = outside height of the ellipsoidal head measured from the tangent line (head-bend line), in.

K_o = factor depending on the ellipsoidal head proportions $D_o/2h_o$ (see Table 3)

R_o = for torispherical heads, the outside radius of the crown portion of the head, in.

= for ellipsoidal heads, the equivalent outside spherical radius taken as $K_o D_o$, in.

8.3 TOLERANCES FOR FORMED HEADS

Formed heads shall meet the tolerances specified in UG-81. Additionally, the maximum local deviation from true circular form, e , for spherical shells and any spherical portion of a formed head designed for external pressure shall not exceed the shell thickness. Measurements to

determine e shall be made with a gage or template with the chord length L_e given by the following equation:

$$L_e = 3.72\sqrt{Rt} \quad (8-7)$$

9 REINFORCEMENT FOR OPENINGS

The reinforcement for openings in vessels that do not exceed 25% of the cylinder diameter or 80% of the ring spacing into which the opening is placed may be designed in accordance with the following rules. Openings in shells that exceed these limitations require a special design that considers critical buckling performed in accordance with the rules of Division 1, U-2(g) as applicable, in addition to the rules provided in this Case. Small nozzles that do not exceed the size limitations in UG-36(b)(3) are exempt from reinforcement calculations.

9.1

Reinforcement for nozzle openings in vessels designed for external pressure alone shall be in accordance with the requirements of UG-37(d)(1) as applicable. The required thickness shall be determined in accordance with 3.1 or 4.1.

Openings that exceed dimensional limits given in UG-36(b)(1) shall meet the requirements of Appendix 1-7.

9.2

For cylinders designed for axial compression (which includes axial load and/or bending moment) without external pressure, the reinforcement of openings shall be in accordance with the following:

$$\text{Where } \gamma_n = \left(\frac{d}{2\sqrt{Rt}} \right)$$

For $d \leq 0.4\sqrt{Rt}$

$$A_r = 0 \quad (9-1)$$

For $d > 0.4\sqrt{Rt}$ and $\gamma_n \leq \left(\frac{R/t}{291} + 0.22 \right)^2$

$$A_r = 0.5dt_r \quad (9-2)$$

For $d > 0.4\sqrt{Rt}$ and $\gamma_n > \left(\frac{R/t}{291} + 0.22 \right)^2$

$$A_r = 1.0dt_r \quad (9-3)$$

and A_r is the area of reinforcement required, d is the inside diameter of the opening and t_r is the thickness of shell required for the axial compression loads without external pressure. The reinforcement shall be placed within a distance of $0.75\sqrt{Rt}$ from the edge of the opening. Reinforcement available from the nozzle neck shall be limited to a thickness not exceeding the shell plate thickness at the nozzle attachment, and be placed within a limit measured normal to the outside surface of the vessel shell of $0.5\sqrt{(d/2)t_n}$ (but not exceeding $2.5 \times t_n$), where t_n is the nozzle wall thickness.

9.3

For cylinders designed for axial compression in combination with external pressure, the reinforcement shall be the larger of that required for external pressure alone 9.1 or axial compression alone 9.2. Required reinforcement shall be placed within the limits described in 9.2 above.

10 REFERENCES

API 2U (1987), API Bulletin 2U (BUL 2U), "Bulletin on Stability Design of Cylindrical Shells," prepared under the jurisdiction of the API Committee on Standardization of Offshore Structures, First Edition, May 1987.

"ASME Code Case N-284: Metal Containment Shell Buckling Design Methods," Revision 1, May 1991.

Welding Research Council Bulletin 406, "Proposed Rules for Determining Allowable Compressive Stresses for Cylinders, Cones, Spheres, and Formed Heads," C.D. Miller and K. Mokhtarian, November 1995, ISSN 0043-2326.

Miller, C.D. and Mokhtarian, K., (1996), "A Comparison of Proposed Alternative Rules with ASME Code Rules for Determining Allowable Compressive Stresses," The Eighth International Conference on Pressure Vessel Technology, Montreal, Canada, July 25, 1996.

Miller, C.D. and Saliklis, E.P. (1993), "Analysis of Cylindrical Shell Database and Validation of Design Formulations," API Project 90-56, October 1993.

Miller, C.D., "Experimental Study of the Buckling of Cylindrical Shells With Reinforced Openings," ASME/ANS Nuclear Engineering Conference, Portland, Oregon, July 1982.

Miller, C.D., "The Effect of Initial Imperfections on the Buckling of Cylinders Subjected to External Pressure," PVRC Grant 94-28. Welding Research Council Bulletin 443, Report No. 1, July 1999.

"Commentary on the Alternative Rules for Determining Allowable Compressive Stresses for Cylinders, Cones, Spheres, and Formed Heads for Section VIII, Divisions 1 and 2," PVRC Grant 99-07, Welding Research Council Bulletin 462, June 2001.

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Case 2297

F-Number Grouping for 9Cr-1Mo-V FCAW Consumable

Section I; Section II, Part A; Section II, Part B; Section II, Part C; Section II, Part D; Section IV; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX; Section X; Section XII; Section III, Division 1; Section III, Division 2; Section III, Division 3; Section III, Division 5; Section XI, Division 1

Approval Date: November 30, 1999

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternative rules may be applied to grouping welding filler metal meeting the chemical requirements of [Table 1](#) and mechanical properties of [Table 2](#) but otherwise conforming to AWS A5.29 to reduce the number of performance qualifications?

Reply: It is the opinion of the Committee that welding filler metal meeting the chemical requirements of [Table 1](#) and mechanical properties of [Table 2](#) but otherwise conforming to AWS A5.29 may be considered as an F-No. 6 for performance qualifications only. Separate procedure qualifications are required.

This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.08–0.13
Manganese	0.70–1.3
Phosphorus, max.	0.015
Sulfur, max.	0.015
Silicon	0.15–0.25
Chromium	8.5–10.5
Molybdenum	0.85–1.20
Vanadium	0.18–0.30
Nickel, max.	0.40
Columbium	0.02–0.040
Aluminum, max.	0.01
Copper, max.	0.40
Nitrogen	0.03–0.055
Cobalt, max.	0.6

Table 2
Mechanical Property Requirements
(All Weld Metal Tension Test)

Tensile strength, min., ksi	90
Elongation in 2 in., min. %	17

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Case 2300

Use of SA-372 Grade E Class 55, Grade J Class 55, and Grade F, G, and H Class 55 and 65 Forgings, Quenched and Tempered

Section VIII, Division 1

Approval Date: September 23, 1999

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May liquid-quenched and tempered forging material complying with SA-372 Grade E Class 55, Grade J Class 55, and Grade F, G, and H Class 55 or 65 be used for pressure vessels fabricated by forging in construction under Section VIII, Division 1?

Reply: It is the opinion of the Committee that liquid-quenched and tempered forging material as described in the inquiry may be used for pressure vessels fabricated

by forging in construction under Section VIII, Division 1, provided the following additional requirements are met:

(a) The rules in Section VIII, Division 1, Subsection B, that apply are those given in Part UF.

(b) The maximum allowable stress values for the materials shall be those given in Table 1. The stress values apply to quenched and tempered material only, as per the specification.

(c) This material shall not be used for external pressure design.

(d) This Case number shall be referenced in the documentation of the material and recorded on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

Nominal Composition	Grade	Specified Min. Yield, ksi	Specified Min. Tensile, ksi	Maximum Allowable Stress Values, ksi for Metal Temperatures of 100–600°F
1Cr- $\frac{1}{5}$ Mo	E, Class 55	55	85	24.3
1Cr- $\frac{1}{5}$ Mo	F, Class 55	55	85	24.3
1Cr- $\frac{1}{5}$ Mo	F, Class 65	65	105	30.0
$\frac{1}{2}$ Cr- $\frac{1}{2}$ Mo	G, Class 55	55	85	24.3
$\frac{1}{2}$ Cr- $\frac{1}{2}$ Mo	G, Class 65	65	105	30.0
$\frac{1}{2}$ Cr- $\frac{1}{2}$ Mo	H, Class 55	55	85	24.3
$\frac{1}{2}$ Cr- $\frac{1}{2}$ Mo	H, Class 65	65	105	30.0
1Cr- $\frac{1}{5}$ Mo	J, Class 55	55	85	24.3

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

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Case 2304-2

Austenitic Fe-35Ni-27Cr Alloy (UNS S35045)

Section I; Section VIII, Division 1

Approval Date: May 12, 2004

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May annealed austenitic Fe-35Ni-27Cr alloy (UNS S35045) wrought sheet, strip, plate, rod, bar, seamless and welded pipe and tube, fittings, and forgings, with the chemical analysis shown in Table 1 and minimum mechanical properties shown in Table 2 and otherwise conforming to one of the specifications given in Table 3, be used in welded construction under the rules of Section I and Section VIII, Division 1?

Reply: It is the opinion of the Committee that material described in the Inquiry may be used in Section I and Section VIII, Division 1 construction at a design temperature of 1,650°F (900°C) or less, provided the following additional requirements are met:

(a) The rules in Section VIII, Division 1 that shall apply are those given in Part UNF for nickel alloys.

(b) For Section I design the y values (see PG-27.4 notes) used for PG-27.2.2 shall be as follows:

$\leq 1150^{\circ}\text{F}$ (620°C)	$y = 0.4$
1200°F (650°C)	$y = 0.5$
$\geq 1250^{\circ}\text{F}$ (675°C)	$y = 0.7$

(c) The maximum allowable stress values for the material shall be those given in Tables 4 (U.S. Customary Units) and 4M (SI Metric Units). The maximum design temperature shall be 1,650°F (900°C). For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

(d) Separate welding procedures and performance qualifications shall be conducted for the material in accordance with Section IX.

(e) Heat treatment after forming or fabrication is neither required nor prohibited.

(f) For external pressure values, use Fig. NFN-9 of Section II, Part D.

(g) This Case number shall be shown on the material certification, on the material, and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition Limits, %
Nickel	32.0–37.0
Chromium	25.0–29.0
Iron [Note (1)]	Balance
Manganese, max.	1.5
Carbon	0.06–0.10
Silicon, max.	1.0
Sulfur, max.	0.015
Aluminum	0.15–0.60
Titanium	0.15–0.60
Copper, max.	0.75

NOTE: (1) This element shall be determined arithmetically by difference.

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength min. (ksi)	70
Yield strength 0.2% offset min. (ksi)	25
Elongation in 2 in. gage or 4D min. (%)	35

Table 3
Product Specifications

Fittings	SA-403
Forgings	SA-182
Plate, sheet, and strip	SA-240
Rod and bar	SA-479
Seamless and welded pipe	SA-312
Seamless tubing	SA-213
Welded tubing	SA-249

Table 4
Maximum Allowable Stress Values, U.S. Customary Units
[Note (1)]

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi	
-20-100	16.7,	16.7
200	14.6,	16.7 [Note (2)]
300	13.6,	16.7 [Note (2)]
400	12.3,	16.7 [Note (2)]
500	12.1,	16.4 [Note (2)]
600	11.7,	15.8 [Note (2)]
650	11.5,	15.5 [Note (2)]
700	11.3,	15.3 [Note (2)]
750	11.2,	15.1 [Note (2)]
800	11.1,	15.1 [Note (2)]
850	11.0,	14.9 [Note (2)]
900	10.9,	14.7 [Note (2)]
950	10.8,	14.6 [Note (2)]
1,000	10.7,	14.5 [Note (2)]
1,050	10.6,	13.7 [Note (2)]
1,100	10.5,	10.9 [Note (2)]
1,150	8.8,	8.8
1,200	7.1,	7.1
1,250	5.8,	5.8
1,300	4.7,	4.7
1,350	3.8,	3.8
1,400	3.1,	3.1
1,450	2.5,	2.5
1,500	2.0,	2.0
1,550	1.5,	1.5
1,600	1.2,	1.2
1,650	0.90,	0.90

NOTES:

- (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 4M
Maximum Allowable Stress Values, SI Metric Units
[Note (1)]

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, Max., MPa	
-30-40	115,	115
65	115,	101.2 [Note (2)]
100	115,	99.6 [Note (2)]
150	115,	93.1 [Note (2)]
200	115,	88.0 [Note (2)]
250	114,	84.1 [Note (2)]
300	109,	81.1 [Note (2)]
325	108,	79.9 [Note (2)]
350	106,	78.8 [Note (2)]
375	105,	77.9 [Note (2)]
400	104,	77.1 [Note (2)]
425	103,	76.4 [Note (2)]
450	102,	75.2 [Note (2)]
475	102,	75.2 [Note (2)]
500	101,	74.6 [Note (2)]
525	100,	74.0 [Note (2)]
550	99.1,	73.4
575	87.4,	72.7
600	71.8,	71.8
625	58.9,	58.9
650	48.5,	48.5
675	40.1,	40.1
700	33.3,	33.3
725	27.8,	27.8
750	23.2,	23.2
775	19.2,	19.2
800	15.7,	15.7
825	12.6,	12.6
850	9.8,	9.8
875	7.6,	7.6
900	6.4,	6.4

NOTES:

- (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Case 2305-1

Exemption From Postweld NDE Requirements of UG-93(d)(4)(-b) on Fig. UW-13.2(d) Construction

Section VIII, Division 1

Approval Date: December 14, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may vessels constructed to Fig. UW-13.2(d) be exempted from the postweld NDE requirements of UG-93(d)(4)(-b)?

Reply: It is the opinion of the Committee that vessels constructed to Fig. UW-13.2(d) may be exempted from the postweld NDE requirements of UG-93(d)(4)(-b) provided the following requirements are met:

(a) t_s shall not be thicker than $\frac{3}{16}$ in.

(b) The flat plate pre-machined nominal thickness shall not be thicker than $1\frac{1}{2}$ in.

(c) Materials for construction are limited to P-No. 1, Groups 1 and 2, and P-No. 8, Group 1.

(d) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2318

Alternative Flanged Joint Design for Nuclear Material Fluidized Bed Reactors

Section VIII, Division 1

Approval Date: September 23, 1999

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a vessel for nuclear material fluidized bed reactors intended for lethal service use a slip-on flange as a body flange?

Reply: It is the opinion of the Committee that a vessel for nuclear material fluidized bed reactors intended for lethal service may use a slip-on flange as a body flange provided all of the following conditions are met:

- (a) The vessel does not exceed NPS 6 or 0.280-in. nominal wall thickness.
- (b) The material is limited to N06600.
- (c) Final weld surfaces are liquid penetrant examined in accordance with Appendix 8 of UW-2(a)(1)(-b).
- (d) The flange is welded as shown in Appendix 2, Fig. 2-4(10a) of UW-2(a)(1)(-b).
- (e) The maximum allowable working pressure does not exceed 150 psig.
- (f) The maximum allowable working pressure shall not exceed 1000°F.
- (g) The User shall stipulate to the Manufacturer that
 - (1) the vessel is operated within an engineered enclosure providing secondary containment

(2) the enclosure shall be maintained at a negative pressure during all modes of operation

(3) the enclosure shall be equipped with redundant leak detectors inside with both local and remote alarms

(4) the process shall be shut down if a detector is actuated

(h) The User shall stipulate to the Manufacturer that a hazard analysis will be conducted by an engineer experienced in the applicable analysis methodology that examines all credible scenarios that could result in a leak. The User shall also stipulate to the Manufacturer that the enclosure shall be designed to contain the contents from a leak. The results of the analysis shall be documented and signed by the individual identified to be in charge of the operation of the vessel.

(i) The User shall stipulate to the Manufacturer that documentation of the hazard analysis shall be made available to the regulatory and enforcement authorities having jurisdiction at the site where the vessel will be installed. The User of this Case is cautioned that prior jurisdictional acceptance may be required.

(j) Pressure testing in accordance with UG-99(c) is required.

(k) Provisions of this Case apply only to nonreactor nuclear facilities.

(l) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2321-1

Exemption From Postweld Heat Treatment for P-No. 4 or P-No. 5A Tube-to-Tubesheet Seal Welds

Section VIII, Division 1

Approval Date: February 20, 2002

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may tube-to-tubesheet seal welds between P-No. 4 or P-No. 5A tubes and P-No. 8 or P-No. 4X cladding on P-No. 1 tubesheets be exempt from postweld heat treatment requirements of UCS-56?

Reply: It is the opinion of the Committee that tube-to-tubesheet seal welds between P-No. 4 or P-No. 5A tubes and P-No. 8 or P-No. 4X cladding on P-No. 1 tubesheets may be exempted from postweld heat treatment requirements of UCS-56 under the following limitations:

(a) The P-No. 4 or P-No. 5A tubes shall have a wall thickness less than or equal to 0.150 in.

(b) The tubes are seal welded to the face of the cladding using the GTAW process.

(c) The cladding is deposited using F-No. 4X filler metal or deposited using F-No. 6 filler metal having a deposit chemistry of A-No. 8.

(d) The filler metal used to weld the tubes to P-No. 4X cladding is F-No. 4X filler metal. The filler metal used to weld the tubes to the P-No. 8 cladding is F-No. 4X or F-No. 6 filler metal having a deposit chemistry of A-No. 8.

(e) The vessel is not for lethal [UW-2(a)] service applications.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2324-1

Use of Automated Ultrasound Leak Detection System in Lieu of Visual Inspections Required by UG-100(d)

Section VIII, Division 1

Approval Date: March 21, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an automated ultrasound monitored leak detection system be used in lieu of the visual inspections required by UG-100(d)?

Reply: It is the opinion of the Committee that an automated ultrasound monitored leak detection system may be used in lieu of the visual inspections required by UG-100(d), provided that all of the following requirements are met:

(a) The materials of construction shall be P-No. 1 Group 1 or Group 2 and the weld thickness shall not exceed $\frac{3}{8}$ in. The vessel will not contain a "lethal" substance.

(b) The vessel design pressure shall not exceed 350 psi. The vessel shall be pressurized pneumatically, and the pressure in the vessel during the leak test shall meet the requirements of UG-100(d). All weld seams, which will be hidden by assembly, shall be given a visual examination for workmanship prior to assembly.

(c) The test shall be performed in an acoustically sealed chamber that is monitored by an array of ultrasound transducers capable of detecting the high-frequency emissions (20 kHz and higher) produced by a leak in the pressure vessel being tested. The ultrasound sensors shall be

positioned so that the entire pressure vessel is monitored following the pressurization to detect leakage. The detection of any leakage shall be cause for rejection.

(d) The automated ultrasound leak inspection shall be monitored in accordance with a written procedure that includes the following:

(1) Calibrations of the airborne ultrasound leak detection system shall be conducted in accordance with methods and criteria of ASTM E1002-11 test method A, pressurization.

(2) A test shall be performed once each shift to verify the operation of the entire system. The test must confirm the ultrasound arrays are working properly and confirm the operability of any vessel routing sensors, conveyors, and related devices. This test shall be performed using a white noise to simulate a leak. Date, time, and operator initials confirming acceptance shall be recorded.

(3) The white noise calibration shall be validated at least once per month by demonstrating the system's ability to detect a leak through a 0.001 in. test orifice installed in a vessel.

(4) The manufacturer shall certify that personnel performing the calibration testing have been qualified and certified in accordance with their employer's written practices. The qualification records of certified personnel shall be maintained by their employer.

(e) This Case number shall be shown on the Manufacturer's Data Report Form.

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Case 2327-4

9Cr-1Mo-1W-Cb Material

(25)

Section I

Approval Date: February 3, 2025

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the following 9Cr-1Mo-1W-Cb steel products be used in Section I construction?

(a) seamless tubes and pipes, seamless fittings, forgings, and plates conforming to the specifications listed in [Table 1](#)

(b) forged and bored pipes, with the chemical analysis shown in [Table 2](#), the minimum mechanical properties shown in [Table 3](#), and otherwise conforming to SA-369

Reply: It is the opinion of the Committee that the materials described in the Inquiry may be used in Section I construction, provided the following additional requirements are met:

(a) The material shall be austenitized within the temperature range of 1,900°F to 1,975°F (1040°C to 1080°C), followed by air or accelerated cooling, and tempered within the range of 1,365°F to 1,435°F (740°C to 780°C).

(b) The maximum allowable stress values for the material shall be those shown in [Tables 4](#) and [4M](#).

(c) The maximum use temperature is 1,150°F (621°C).

(d) Separate welding procedure qualifications shall be conducted in accordance with Section IX. For purposes of performance qualification, this material shall be considered P-No. 15E. Procedures and performance qualifications qualified under previous versions of this Case do not require requalification, provided that the maximum PWHT temperature shown on the WPS is limited to that prescribed by [\(e\)\(2\)](#) or [\(e\)\(3\)](#), as applicable.

(e) Postweld heat treatment (PWHT) for this material is mandatory, and the following rules shall apply:

(1) The time requirements shall be those given for P-No. 15E, Group 1 materials in [Table PW-39-5](#).

(2) The PWHT temperature range shall be 1,350°F to 1,435°F (730°C to 780°C) if Grade 91 type consumables are used (e.g., -B91 or ISO CrMo91). All -B91 or ISO CrMo91 filler metals shall be limited to 1.2% max. Mn + Ni.

(3) For weld consumables other than grade 91 mentioned in [\(2\)](#), experimental measurement of the weld deposit's lower critical temperature (LCT) on a

heat-lot basis shall be determined before use. The experimental measurement shall be performed in accordance with a relevant standard. The maximum permitted PWHT temperature shall not exceed the lesser of 1,435°F (780°C) or the weld deposit's LCT. The minimum PWHT shall be 1,350°F (730°C).

(f) Material cold worked to strains greater than 10% and up to and including 20%,¹ and intended for use above 1,000°F (540°C), shall be stress relieved at 1,365–1,435°F (740–780°C). Stress relief may be combined with the PWHT. Material cold worked to strains greater than 20%,¹ and intended for use above 1,000°F (540°C), shall be re-austenitized and retempered, per [\(a\)](#). Normalizing and tempering are required for all cold swages, flares, and upsets regardless of the amount of strain.

(g) Except as provided in [\(h\)](#), if during the manufacturing any portion of the component is heated to a temperature greater than 1,435°F (780°C), then the component must be re-austenitized and retempered in its entirety in accordance with [\(a\)](#) above, or that portion of the component heated above 1,435°F (780°C), including the overheated zone created by the local heating, must be replaced, or must be removed, re-austenitized, and retempered, and then replaced in the component.

(1) For components with weld deposits, the following requirement shall apply when the PWHT temperature has locally exceeded the lower critical temperature of the weld deposit [see [\(e\)\(3\)](#)] but has not exceeded 1,435°F (780°C). The entire weld deposit shall be removed and rewelded followed by PWHT.

(2) Alternatively, a section including the weld zone and an appropriate length of material on either side of the weld zone must be replaced, or removed, re-austenitized, and retempered in accordance with [\(a\)](#) except the retempering parameters shall additionally meet the applicable PWHT limitations of [\(e\)\(1\)](#) through [\(e\)\(3\)](#) as applicable.

(h) If the design stress values to be used are less than or equal to the allowable stress values provided in [Table 1A](#) of Section II, Part D for Grade 9 (SA-213 T9, SA-335 P9, or equivalent product specifications) at the design temperature, then the requirements of [\(g\)](#) may be waived, provided the overheated portion of the component is reheat treated within the temperature range 1,350°F

¹ See PG-19 for applicable strain definitions.

to 1,435°F (730°C to 780°C) but not to exceed the LCT of any weld deposits.

(i) This material is a creep strength enhanced ferritic steel, whose creep temperature strength is enhanced by the creation of a precise condition of microstructure, specifically tempered martensite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbo-nitrides, or other stable and/or meta-stable phases. Refer to Section I, PW-10 for additional cautionary information. CSEF alloys may demonstrate a susceptibility to creep-intolerant behavior, which manifests as limited amount of plastic deformation at the time of creep-rupture.

(j) This Case number shall be shown in the marking and documentation of the material and in the Manufacturer's Data Report.

CAUTION: This material has demonstrated a susceptibility to creep cavity formation and damage in the time-dependent regime resulting in very low strain before rupture and high sensitivity to multiaxial stresses (e.g., trending to notch weakening behavior). The accumulation of creep damage is known to contribute to a decreased life expectancy.

**Table 1
Specifications**

Product	Specification
Seamless tubes	SA-213/SA-213M, Grade T911
Seamless pipes	SA-335/SA-335M, Grade P911
Fittings	SA-234/SA-234M, Grade WP911
Forgings	SA-182/SA-182M, Grade F911; SA-336/SA-336M, Grade F911
Plates	SA-1017/SA-1017M, Grade 911

**Table 2
Chemical Requirements**

Element	Composition Limits, %
Carbon	0.09–0.13
Manganese	0.30–0.60
Phosphorous, max.	0.020
Sulfur, max.	0.010
Silicon	0.10–0.50
Chromium	8.5–9.5
Molybdenum	0.90–1.10
Tungsten	0.90–1.10
Nickel, max.	0.40
Vanadium	0.18–0.25
Columbium	0.060–0.100
Nitrogen	0.040–0.090
Aluminum, max.	0.02
Boron	0.0003–0.006
Titanium, max.	0.01
Zirconium, max.	0.01

Table 3
Mechanical Property Requirements

Product Form	Tensile Strength, ksi (MPa)	Yield Strength, ksi (MPa)	Elongation in 2 in. (50 mm) min., % [Note (1)]	Hardness, max.
Forged and bored pipe	90 (620)	64 (440)	20	238 HB/250 HV (99.5 HRB)
Wall Thickness, in. (mm)		Elongation in 2 in. (50 mm), min., %		
$\frac{5}{16}$ (8.0)		20.0		
$\frac{9}{32}$ (7.2)		19.0		
$\frac{1}{4}$ (6.4)		18.0		
$\frac{7}{32}$ (5.6)		17.0		
$\frac{3}{16}$ (4.8)		16.0		
$\frac{5}{32}$ (4.0)		15.0		
$\frac{1}{8}$ (3.2)		14.0		
$\frac{3}{32}$ (2.4)		13.0		

GENERAL NOTE: The above table gives the computed minimum elongation values for each $\frac{1}{32}$ in. (0.8 mm) decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value shall be determined by the following equation:

(U.S. Customary Units)

$$E = 32t + 10.0$$

(SI Units)

$$E = 1.25t + 10.0$$

where

E = elongation in 2 in. (50 mm), %

t = actual thickness of specimen, in. (mm)

NOTE: (1) For longitudinal strip tests of tubes and pipes, a deduction from the basic minimum elongation values of 1.00% for each $\frac{1}{32}$ in. (0.8 mm) decrease in wall thickness below $\frac{5}{16}$ in. (8.0 mm) shall be made. The table above gives the computed value.

Table 4
Material Property Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Yield Strength Values, ksi [Note (1)]	Tensile Strength Values, ksi [Note (2)]
-20 to 100	25.7	64.0	90.0
200	25.7	60.2	90.0
300	25.1	57.5	87.7
400	24.1	55.6	84.5
500	23.6	54.5	82.5
600	23.2	53.9	81.1
650	23.0	53.5	80.3
700	22.7	53.1	79.3
750	22.3	52.5	77.9
800	21.7	51.5	76.0
850	21.0	50.3	73.5
900	20.1	48.6	70.3
950	19.0	46.5	66.5
1,000	17.7	44.0	62.0
1,050	14.4 [Note (3)]	41.1	56.9
1,100	10.6 [Note (3)]	37.9	51.4
1,150	7.3 [Note (3)]	34.5	45.8
1,200	...	31.0	40.3

NOTES:

- (1) The tabulated values of yield strength are those the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to minimum, as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to "average," as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (3) These stress values are obtained from time-dependent properties.

Table 4M
Material Property Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Yield Strength Values, MPa [Note (1)]	Tensile Strength Values, MPa [Note (2)]
-28 to 40	177	441	621
65	177	429	621
100	177	412	620
125	175	404	614
150	173	396	604
175	170	390	594
200	167	384	584
225	165	380	577
250	163	377	571
275	162	375	566
300	161	373	562
325	160	371	557
350	158	368	552
375	156	366	546
400	154	362	537
425	150	356	525
450	146	348	510
475	140	338	491
500	134	326	468
525	127	312	442
550	115	295	412
575	90.3 [Note (3)]	276	380
600	67.0 [Note (3)]	256	345
625	47.4 [Note (3)], [Note (4)]	235	310
650	...	213	276

NOTES:

- (1) The tabulated values of yield strength are those the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to minimum, as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to "average," as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (3) These stress values are obtained from time-dependent properties.
- (4) The value at 625°C is for interpolation only. The maximum permitted use temperature is 621°C.

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Case 2334

Single Fillet Lap Joints in the Shell of a Shell-and-Tube Heat Exchanger

Section VIII, Division 1

Approval Date: July 10, 2000

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a single fillet lap joint weld be used to join a cast tubesheet with flange extension to the shell in a shell-and-tube heat exchanger?

Reply: It is the opinion of the Committee that a single fillet lap joint weld may be used to join a cast tubesheet with flange extension to the shell in a shell-and-tube heat exchanger provided the following requirements are met.

(a) Outside diameter of the shell shall not exceed 12 in., and the nominal thickness of the shell (t_s) shall not exceed $\frac{1}{4}$ in.

(b) The fillet weld shall be attached on the outside and shall be examined by either magnetic particle or liquid penetrant methods after welding. The fillet weld shall meet the minimum cross-sectional requirements shown in [Figure 1](#). A joint efficiency of 0.45 shall be used for this joint.

(c) MAWP on the shell side or the tube side shall not exceed 250 psig.

(d) Maximum design metal temperature (MDMT) shall not exceed 450°F.

(e) MDMT stamped on the nameplate shall not be colder than -20°F .

(f) Cyclic loading is not a controlling design requirement (see UG-22).

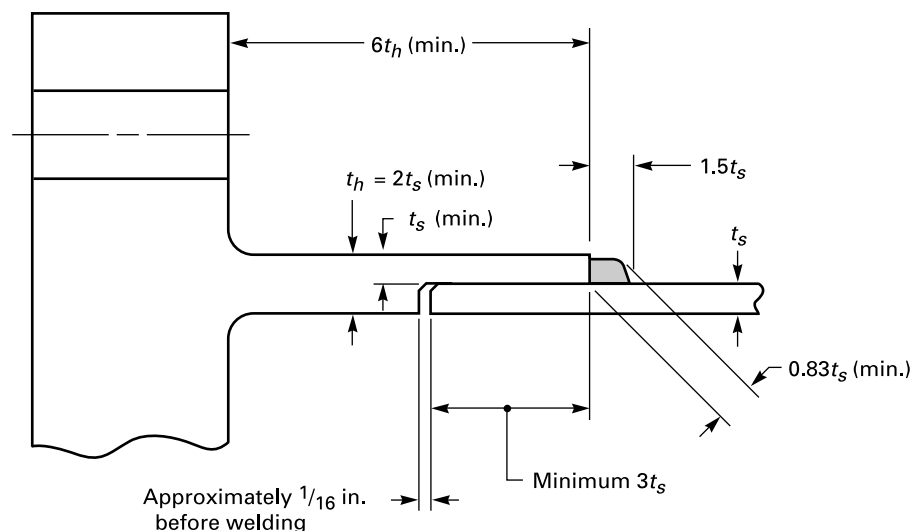
(g) The heat exchanger is not in lethal service (see UW-2).

(h) The tubesheet shall be supported such that at least 80% of the pressure load on the tubesheet is carried by tubes, stays, or braces.

(i) The tubesheet shall be a casting that has an integral flange and shell hub. The shell hub shall extend at least six times the hub thickness beyond the back of the tubesheet and meet the dimensional requirements of [Figure 1](#). The casting material shall be either P-No. 1 or 8, or per UNF-8.

(j) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1



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Case 2346-1

Alternative Rules for Ellipsoidal or Torispherical Heads Having Integral Backing Strip Attached to Shells

Section VIII, Division 1

Approval Date: February 14, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ellipsoidal or torispherical heads having an integral backing strip be attached to shells?

Reply: It is the opinion of the Committee that an ellipsoidal or torispherical head having an integral backing strip be attached to shells provided the following requirements are met.

- (a) MAWP on the vessel shall not exceed 470 psig.
- (b) Maximum design metal temperature shall not exceed 400°F.
- (c) MDMT stamped on the nameplate shall not be colder than -20°F.
- (d) Cyclic loading is not a controlling design requirement (see UG-22).
- (e) The vessel is not in lethal service (see UW-2).
- (f) The straight flange (skirt) of the head is machined to form an integral backing strip meeting the requirements of [Figure 1](#).

(g) Outside diameter of the formed head and shell shall not exceed 30 in. and the overall vessel length shall not exceed 96 in.

(h) The required thickness of the formed head shall not exceed $\frac{5}{8}$ in. The thickness of the head straight flange shall be at least that required for a seamless shell of the same outside diameter.

(i) The required thickness of the shell shall not exceed $\frac{7}{16}$ in.

(j) Heads shall have a driving force fit before welding.

(k) The joint efficiency of the head-to-shell joint shall be determined from Table UW-12 for a Type 2 joint depending on the degree of radiographic examination. The limitations in Table UW-12 for the Type 2 joints do not apply.

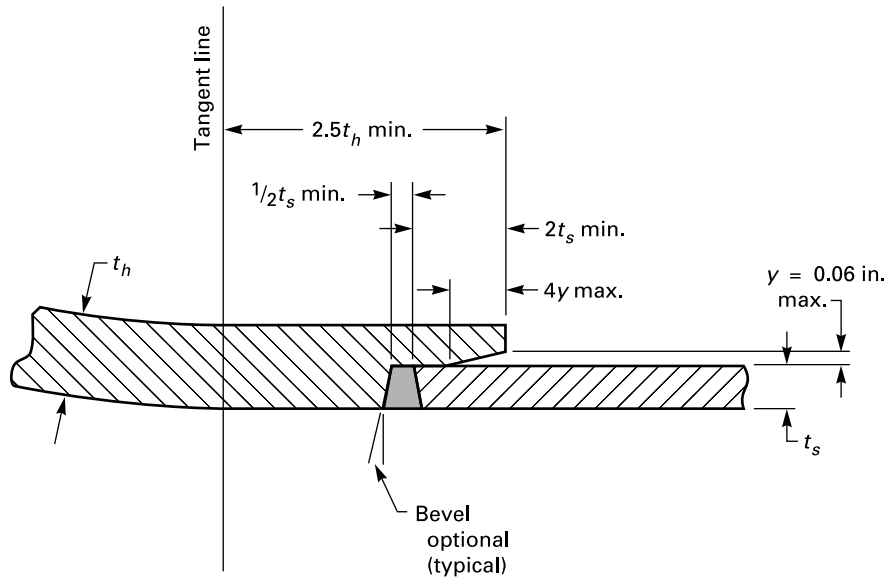
(l) The materials of construction shall be P-No. 1, Group 1 or 2.

(m) If this Case is used for vessels in chlorine services the requirements of the Chlorine Institute Pamphlet 17¹ shall apply.

(n) This Case number shall be shown on the Manufacturer's Data Report.

¹ Pamphlet 17 can be obtained from The Chlorine Institute, Inc., 2001 L Street NW, Suite 506, Washington, DC 20036

Figure 1



Case 2350

Strength of Aluminum Brazed Joints Up to 400°F

Section VIII, Division 1

Approval Date: February 26, 2001

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the upper temperature limit of 350°F shown in column 2 of Table UB-2 be increased to 400°F for brazed joints between aluminum alloy 3003 when BAISi-7 filler metal is used for the construction of brazed plate-fin heat exchangers?

Reply: It is the opinion of the Committee that the upper temperature limit of 350°F shown in Column 2 of Table UB-2 may be increased to 400°F for brazed joints between aluminum alloy 3003 when BAISi-7 filler metal is used for the construction of brazed plate-fin heat exchangers under the following conditions:

(a) The brazing process shall be furnace brazed using braze metal clad sheet or preplaced shim stock brazing filler metal fully covering one surface to be joined.

(b) The minimum time at brazing temperature shall be 15 min.

(c) The joint designs shall be either a plate-fin or a sealing bar (lap) joint.

(d) The width of the brazed joint shall be a minimum of 2.5 times the thickness of the fin.

(e) Above 350°F, the stress in the brazed joint shall not exceed one-half of the allowable stress for the 3003 alloy base material in the "O" temper. The stress in the brazed joint is defined as the force (due to pressure) supported by the joint divided by the area of the joint.

(f) The braze procedure specification shall be qualified in accordance with UB-12 using the minimum holding time that will be used in production.

(g) All other applicable Code requirements shall be met.

(h) This Case number shall be shown on the Data Report.

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Case 2351-1¹

Alternative Rules for Brazing Qualifications

Section VIII, Division 1

Approval Date: November 30, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In lieu of the specified rules in Section IX, what alternative rules for brazing procedure and performance qualifications may be used in fabricating furnace brazed plate-fin heat exchangers in compliance with Section VIII, Division 1?

Reply: It is the opinion of the Committee that, in lieu of the specified rules in Section IX, the following alternative rules for brazing procedure and performance qualifications may be used in fabricating furnace brazed plate-fin heat exchangers in compliance with Section VIII, Division 1.

1 ALTERNATIVE TESTS AND EXAMINATIONS

1.1 TENSION TEST OF BASE METAL

1.1.1 Purpose. Tension tests are used to verify that the ultimate strength of the base material subjected to heating in a brazing cycle meets minimum tensile requirements.

1.1.2 Specimens. Test specimens of the same material specifications and thickness as used in the brazed vessel shall be processed through a complete brazing temperature cycle. Each tension test specimen shall consist of a single piece of the material (without braze joints) and conform to the dimensions shown in QB-462.1(a) of Section IX.

1.1.3 Test Procedure. The tension test specimen shall be tested to failure under tensile load and the tensile strength measured.

1.1.4 Acceptance Criteria. The test shall be acceptable if the resulting tensile strength is not more than 5% below the minimum specified tensile strength of the base metal in the annealed condition.

1.2 STRENGTH TESTS

1.2.1 Purpose. A test panel shall be brazed and tested to failure to verify that the strength of the braze joint exceeds the strength of the base material.

1.2.2 Specimens. Representative components shall be brazed together into a test panel. The test panel shall accurately represent the materials, thicknesses, and plate pattern of the production configuration in an arrangement acceptable to the Authorized Inspector. A minimum of one plate-fin layer shall be assembled, complete with sealing bars and separation plates. The test panel need not exceed three plate-fin layers. All brazed joints in the test panel shall be the same size, shape, and overlap as those on the production vessel. Provisions for adequately filling and venting the test panel shall be provided.

1.2.3 Test Procedure. The test panel is pressurized to the point of failure in the presence of the Authorized Inspector.

1.2.4 Acceptance Criteria. The test is considered acceptable if the failure occurs in the base material.

1.3 WORKMANSHIP COUPONS

1.3.1 Purpose. Workmanship coupons are used to determine the soundness of the brazed joints.

1.3.2 Specimens. The dimensions and configuration of the workmanship coupon shall be sufficient to represent a cross section of the maximum width of each brazed joint used on the production vessel. Each plate-fin and sealing bar brazed joint design used in production under these rules shall be examined and evaluated independently.

1.3.3 Test Procedure. After completion of the strength test, the test panel shall be sectioned in two roughly parallel cuts across the width of the braze joints, and the outer sections discarded. Care should be taken to avoid making the cuts in the vicinity of any ruptured areas. Each cut edge face of the remaining center section shall be polished, and each brazed area examined with at least four-power magnification.

1.3.4 Acceptance Criteria The collective sum of the lengths of all indications of unbrazed areas for each individual edge shall not exceed 20% of the length of the joint overlap.

¹There is no change to this reinstated Case.

Table 1
Tension, Workmanship, and Strength Tests

	Thickness Range of Materials Qualified		Type and Number of Test Specimens Required		
	Min.	Max.	Tension	Workmanship	Strength
Specimen Thickness, T (as Brazed)	$0.5T$	$2T$	2	1	1

2 BRAZING PROCEDURE QUALIFICATIONS

2.1 TENSION, WORKMANSHIP, AND STRENGTH TESTS

The type and number of test specimens required to qualify a Brazing Procedure Specification, and the qualified thickness range of base materials, are shown in [Table 1](#).

2.2 RE-TESTS

The failure of any test specimen to meet the required acceptance criteria shall require preparation and testing of a new test specimen.

2.3 VARIABLES FOR BRAZING PROCEDURE QUALIFICATIONS

The Essential and Nonessential variables applicable to this qualification process shall be those listed in QB-253 of Section IX except as follows:

2.3.1 The thickness range qualified shall be as shown in [Table 1](#) of this Case, in lieu of the requirements of QB-402.3.

2.3.2 The requirements for overlap length for lap joints specified in QB-408.4 shall be applied.

3 BRAZING PERFORMANCE QUALIFICATIONS

3.1 TYPE AND NUMBER OF TESTS REQUIRED

Workmanship samples shall be brazed and examined as specified in [1.3](#) of this Case. Both edges of the test specimen shall meet the acceptance criteria specified.

3.2 SIMULTANEOUS PROCEDURE AND PERFORMANCE QUALIFICATION

Brazing operators who successfully prepare Procedure Qualification test coupons meeting the requirements of sections [1](#) and [3](#) of this Case are considered qualified with no further testing required.

3.3 RANGE OF QUALIFICATION

Brazing operators qualified for any Brazing Procedure Specification for furnace brazing under the provisions of this Case, shall also be qualified for all other Brazing Procedure Specifications qualified under the provisions of this Case.

3.4 MAINTENANCE OF QUALIFICATIONS

The maintenance of Brazing Operator Qualifications shall be in accordance with QB-320.

4 DOCUMENTATION

(a) All applicable procedure and performance qualification test documentation required by Section IX, Part QB shall also apply for tests performed using this Case.

(b) This Case number shall be shown on the Manufacturer's Data Report.

Case 2353-2

Use of 1.15Ni-0.65Cu-Mo-Cb (UNS K21001) High-Strength Low Alloy Steel Seamless Pipes, Tubes, Plates, Forgings, and Fittings

Section I

Approval Date: April 23, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May high-strength low alloy steel seamless pipes, tubes, plates, forgings, and fittings from 1.15Ni-0.65Cu-Mo-Cb that conform to specifications and grades listed in [Table 1](#), be used for Section I construction?

Reply: It is the opinion of the Committee that high-strength low alloy seamless pipes, tubes, plates, forgings, and fittings from 1.15Ni-0.65Cu-Mo-Cb that conform to the specifications and grades listed in [Table 1](#) may be used for Section I construction, provided the following requirements are met:

(a) For Class 1 the material shall be normalized at 1,650°F (899°C) minimum and tempered at 1,100°F (595°C) but not higher than 1,200°F (650°C). For Class 2 the material may be normalized at 1,650°F (899°C) minimum and tempered at 1,000°F (540°C) minimum but not higher than 1,150°F (620°C) or may be austenitized at 1,650°F (899°C) minimum, quenched, and then tempered at 1,000°F (540°C) minimum but not higher than 1,150°F (620°C). Both heat treatment conditions are allowable for plates. The minimum tempering time shall be the same as the holding time for postweld heat treatment given in [Table 4](#).

(b) The material shall not exceed a Brinell Hardness Number of 252 HB (265 HV, HRC 25).

(c) The maximum allowable stress values for the material shall be those given in [Tables 2](#) and [2M](#).

(d) Physical properties shall be those listed in [Tables 3](#) and [3M](#).

(e) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. Separate weld procedure and performance qualifications shall apply for both classes of this material.

(f) Postweld heat treatment is mandatory under all conditions. The postweld heat treatment of the Class 1 and Class 2 materials shall be in accordance with the rules specified in [Table 4](#).

(g) After either cold bending to strains in excess of 5% or any hot bending of this material, the full length of the component shall be heat treated in accordance with the requirements specified in [\(a\)](#). (See PG-19 of Section I for method for calculating strain.)

(h) The thickness of plates, fittings, and forgings is limited to 6 in. (150.0 mm).

(i) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Specifications and Grades

Specifications and Grades	Product
SA-213, T36	Tube
SA-335, P36	Pipe
SA-182, F36	Forgings and fittings
SA/EN 10028-2, 15NiCuMoNb 5-6-4	Flat products (plates)

Table 2
Maximum Allowable Stress Values

Tubes According to SA-213, Pipes According to SA-335, Forgings and Fittings According to SA-182		
For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Class 1	Class 2
100	25.7	27.3
200	25.7	27.3
300	25.1	26.6
400	25.1	26.6
500	25.1	26.6
600	25.1	26.6
700	25.1	26.6

Plates According to SA/EN 10028-2				
For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi			
	Product Thickness, <i>T</i> , in.			
	$T \leq 1\frac{1}{2}$	$1\frac{1}{2} < T \leq 2\frac{1}{2}$	$2\frac{1}{2} < T \leq 4$	$4 < T \leq 6$
100	25.7	25.7	25.1	24.6
200	25.7	25.7	25.1	24.6
300	25.1	25.1	24.5	23.9
400	25.1	25.1	24.5	23.9
500	25.1	25.1	24.5	23.9
600	25.1	25.1	24.5	23.9
700	25.1	25.1	24.5	23.9

Table 2M
Maximum Allowable Stress Values

Tubes According to SA-213, Pipes According to SA-335, Forgings and Fittings According to SA-182		
For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Class 1	Class 2
38	178	188
93	178	188
149	173	184
204	173	184
260	173	184
316	173	184
371	173	184

Plates According to SA/EN 10028-2				
For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa			
	Product Thickness, <i>T</i> , mm			
	$T \leq 38$	$38 < T \leq 64$	$64 < T \leq 100$	$100 < T \leq 150$
38	178	178	173	170
93	178	178	173	170
149	173	173	169	165
204	173	173	169	165
260	173	173	169	165
316	173	173	169	165
371	173	173	169	165

Table 3
Physical Properties

For Metal Temperature Not Exceeding, °F	Modulus of Elasticity E , ksi $\times 10^3$	Thermal Expansion, $\times 10^{-6}$ in./in./°F [Note (1)]	Poisson's Ratio	Density, lb/in. ³
70	27.8	6.4	0.30	0.280
200	27.1	6.7	0.30	0.280
300	26.7	6.9	0.30	0.280
400	26.2	7.1	0.30	0.280
500	25.7	7.3	0.30	0.280
600	25.1	7.4	0.30	0.280
700	24.6	7.6	0.30	0.280

NOTE: (1) Mean coefficients of thermal expansion are those from 70°F to indicated temperature.

Table 3M
Physical Properties

For Metal Temperature Not Exceeding, °C	Modulus of Elasticity E , MPa $\times 10^3$	Thermal Expansion, $\times 10^{-6}$ mm/mm/°C [Note (1)]	Poisson's Ratio	Density, kg/m ³
21	191	11.5	0.30	7750
93	187	12.1	0.30	7750
149	184	12.4	0.30	7750
204	181	12.7	0.30	7750
260	177	13.1	0.30	7750
316	173	13.3	0.30	7750
371	169	13.7	0.30	7750

NOTE: (1) Mean coefficients of thermal expansion are those from 20°C to indicated temperature.

Table 4
Requirements for Postweld Heat Treatment (PWHT)

Class	PWHT Temperature, °F (°C)	Holding Time
1	1,100–1,200 (595–650)	Up to 2 in. (50.0 mm) thickness, 1 hr/in. (1 h/25 mm), 15 min minimum Over 2 in. (50.0 mm), add 15 min for each additional 1 in. (25 mm)
2	1,000–1,150 (540–620)	1 hr/in. (1 h/25 mm), $\frac{1}{2}$ hr min.

CAUTION: Corrosion fatigue occurs by the combined actions of cyclic loading and a corrosive environment. In boilers, corrosion fatigue occurs frequently on the water side of economizer tubes and headers, waterwall tubes and headers, risers, downcomers, and drums, with a preference toward regions with increased local stresses. While the mechanisms of crack initiation and growth are complex and not fully understood, there is consensus that the two major factors are strain and waterside environment. Strain excursions of sufficient magnitude to fracture the protective oxide layer play a major role. In terms of the waterside environment, high levels of dissolved oxygen and pH excursions are known to be detrimental. Historically, the steels applied in these water-touched components have had the minimum specified yield strengths in the range of 27 ksi to 45 ksi (185 MPa to 310 MPa) and minimum specified tensile strengths in the range of 47 ksi to 80 ksi (325 MPa to 550 MPa). As these materials are supplanted by higher strength steels, some have concern that the higher design stresses and thinner wall thicknesses will render components more vulnerable to failures by corrosion fatigue. Thus, when employing such higher strength steels for water circuits it is desirable to use "best practices" in design by minimizing localized strain concentrations, in control of water chemistry and during layup by limiting dissolved oxygen and pH excursions, and in operation by conservative startup, shutdown, and turndown practices.

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Case 2357-2

Ni-Fe-Cr Alloy N08801 for Water-Wetted Service

Section I

Approval Date: December 30, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May nickel-iron-chromium alloy N08801, seamless condenser and heat exchanger tubes and seamless pipe and tubes conforming to SB-163 and SB-407 be used in water-wetted service construction in Section I?

Reply: It is the opinion of the Committee that nickel-iron-chromium alloy forms as described in the Inquiry may be used in construction under Section I for water-wetted service, provided the following requirements are met:

(a) The material will be given a 1,725°F (940°C) to 1,825°F (995°C) stabilizing heat treatment.

(b) The maximum allowable stress values for the material shall be those given in Table 1B of Section II, Part D.

(c) Welded fabrication shall conform to the applicable requirements of Section I.

(d) Welds that are exposed to the effects of corrosion should be made using a filler material having a corrosion resistance comparable to that of the base metal.

(e) Heat treatment after forming or fabrication is neither required nor prohibited, but if performed shall be in accordance with (a).

(f) The required thickness for external pressure shall be determined from the chart in Fig. NFN-9 of Section II, Part D.

(g) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

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Case 2359-2

Ni-25Cr-9.5Fe-2.1Al Alloy (UNS N06025)

Section I; Section VIII, Division 1

Approval Date: June 23, 2005

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed Ni-25Cr-9.5Fe-2.1Al Alloy (UNS N06025) wrought forgings, bar (up to 4 in. in diameter), plate, sheet, strip, welded pipe, seamless pipe and tube, and welded tube and fittings with chemical composition conforming to [Table 1](#), mechanical properties conforming to [Table 2](#), and otherwise conforming to the requirements of Specifications SB-163, SB-166, SB-167, SB-168, SB-366, SB-462, SB-516, SB-517, and SB-564 as applicable, be used in Section I for steam service and in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used for construction under the rules of Section I and Section VIII, Division 1, provided the following additional requirements are met:

(a) For Section I use, the y values [see Section I, para. PG-27.4, Note (6)] shall be as follows:

- (1) 1,050°F and below: 0.4
- (2) 1,100°F: 0.5
- (3) 1,150°F and above: 0.7

(b) The rules of Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for nickel alloys.

(c) For external pressure design use Section II, Part D, Fig. NFN-13 for temperatures not exceeding 1,200°F. The external pressure charts do not account for reduction of buckling strength due to creep under long-term loads. The effect of creep on buckling shall be considered at temperatures for which allowable stresses are shown in italics in [Table 3](#).

(d) The maximum allowable stress values for the material shall be those given in [Table 3](#).

(e) For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

(f) Separate weld procedure and performance qualifications, conducted in accordance with Section IX, shall be required for this material.

(g) Heat treatment after welding or fabrication is neither required nor prohibited.

(h) This Case number shall be shown on the documentation and marking of the material and reproduced on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Nickel	Balance
Chromium	24.0–26.0
Iron	8.0–11.0
Aluminum	1.8–2.4
Carbon	0.15–0.25
Silicon, max.	0.50
Sulfur, max.	0.010
Phosphorus, max.	0.020
Yttrium	0.05–0.12

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength, min., ksi	98
Yield strength, 0.2% min., ksi	39
Elongation in 2 in., min., %	30

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)] and [Note (2)]	
100	26.0,	26.0
200	25.5,	26.0 [Note (3)]
300	24.7,	26.0 [Note (3)]
400	23.7,	26.0 [Note (3)]
500	22.7,	26.0 [Note (3)]
600	21.7,	26.0 [Note (3)]
650	21.2,	26.0 [Note (3)]
700	20.8,	26.0 [Note (3)]
750	20.5,	26.0 [Note (3)]
800	20.2,	26.0 [Note (3)]
850	20.0,	26.0 [Note (3)]
900	19.8,	26.0 [Note (3)]
950	19.6,	21.3 [Note (3)]
1,000	<i>16.3,</i>	<i>16.3</i>
1,050	<i>12.3,</i>	<i>12.3</i>
1,100	<i>9.2,</i>	<i>9.2</i>
1,150	<i>6.9,</i>	<i>6.9</i>
1,200	<i>4.1,</i>	<i>4.1</i>
1,250	<i>2.8,</i>	<i>2.8</i>
1,300	<i>2.0,</i>	<i>2.0</i>
1,350	<i>1.5,</i>	<i>1.5</i>
1,400	<i>1.2,</i>	<i>1.2</i>
1,450	<i>0.97,</i>	<i>0.97</i>
1,500	<i>0.80,</i>	<i>0.80</i>
1,550	<i>0.68,</i>	<i>0.68</i>
1,600	<i>0.58,</i>	<i>0.58</i>
1,650	<i>0.51,</i>	<i>0.51</i>
1,700	<i>0.44,</i>	<i>0.44</i> [Note (4)]
1,750	<i>0.37,</i>	<i>0.37</i> [Note (4)]
1,800	<i>0.32,</i>	<i>0.32</i> [Note (4)]

GENERAL NOTES:

- (a) Time-dependent values are shown in italics.
- (b) The criteria used to establish allowable stresses at design temperatures above 1,500°F included consideration of the F_{avg} factor as defined in Appendix 1 of Section II, Part D.
- (c) Creep-fatigue, thermal ratcheting, and environmental effects are increasingly significant failure modes at temperatures in excess of 1,500°F and shall be considered in the design.

(Cont'd)

NOTES:

- (1) This alloy in the solution-annealed condition is subject to severe loss of rupture ductility in the approximate temperature range of 1,200°F to 1,400°F.
- (2) The allowable stress values are based on the revised criterion for tensile strength of 3.5, where applicable.
- (3) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (4) For Section VIII, Division 1 use only.

Case 2377

Radiographic Requirements for SA-612 Steel Plate

Section VIII, Division 1

Approval Date: January 27, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Section VIII, Division 1, UCS-57 requires full radiographic examination of all butt welded joints in P-No. 10C Grade No. 1 materials with thickness greater than $\frac{5}{8}$ in. Under what conditions may steel plate material conforming to specification SA-612 be used in welded construction without the full radiographic requirements of UCS-57?

Reply: It is the opinion of the Committee that steel plate materials conforming to specification SA-612 may be used in welded construction without the full radiographic requirements of UCS-57 provided the following requirements are met:

(a) The plate material shall be normalized and the nominal plate thickness shall not be thicker than 1 in.

(b) The maximum columbium (Cb) content is 0.02% by heat analysis or 0.03% by product analysis.

(c) All of the Category A butt weld joints with thickness greater than $\frac{5}{8}$ in. in the vessel shall be examined 100% by radiography in accordance with UW-51.

(d) All of the Category B and C butt weld joints with thickness greater than $\frac{5}{8}$ in. in the vessel shall be examined by spot radiography in accordance with UW-52.

(e) The completed vessel shall be hydrostatically tested per UG-99(b) or (c).

(f) Design temperature is no warmer than 650°F.

(g) The thermal or mechanical shock loadings are not a controlling design requirement. (See UG-22.)

(h) Cyclical loading is not a controlling design requirement. (See UG-22.)

(i) The vessel shall not be used for lethal service.

(j) This Case number shall be listed on the Manufacturer's Data Report.

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Case 2385-1

37Ni-30Co-28Cr-2.75Si Alloy (UNS N12160)

Section VIII, Division 1

Approval Date: May 4, 2004

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May annealed alloy UNS N12160 wrought sheet, strip, plate, rod, welded pipe and tube, wrought fittings, seamless pipe and tube, wrought fittings, seamless pipe and tube, and forgings, which meet the requirements of the specifications listed in Table 1, be used in welded construction under Section VIII, Division 1 above 1,500°F?

Reply: It is the opinion of the Committee that annealed alloy UNS N12160 wrought sheet, strip, plate, rod, welded pipe and tube, wrought fittings, seamless pipe and tube, and forgings as described in the Inquiry, may be used in the construction of welded pressure vessels complying with the rules of Section VIII, Division 1 above 1,500°F, providing the following additional requirements are met:

(a) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for nickel alloys.

(b) The maximum allowable stress values for the material shall be those given in Table 2. For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

(c) Welding shall be limited to GTAW and GMAW processes using filler metal with the same nominal composition as the base metal. The nominal thickness of the material at the weld shall not exceed 0.5 in.

NOTE: Thickness limitation is due to solidification cracking in sections greater than 0.5 in.

(d) Heat treatment after forming or welding is neither required nor prohibited. When heat treatment is to be employed, the requirements of UNF-56(b) shall apply.

(e) This Case number shall be referenced in the documentation and marking of the material and recorded on the Manufacturer's Data Report.

Table 1
Product Specifications

Sheet, plate, and strip	SB-435
Rod	SB-572
Wrought fittings	SB-366
Forgings	SB-564
Seamless pipe and tube	SB-622
Welded pipe	SB-619
Welded pipe	SB-626

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi [Note (1)] - [Note (4)]
1,550	1.8
1,600	1.5
1,650	1.3
1,700	1.0
1,750	0.85
1,800	0.73

NOTES:

- (1) Stresses are values obtained from time-dependent properties.
- (2) The criteria used to establish allowable stresses at design temperatures above 1,500°F included consideration of the F_{avg} factor as defined in Appendix 1 of Section II, Part D.
- (3) Creep-fatigue, thermal ratcheting, and environmental effects are increasingly significant failure modes at temperatures in excess of 1,500°F and shall be considered in the design.
- (4) Allowable stress values up to and including 1,500°F are in Section II-D, Table 1-B.

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Case 2397-2

Pressure Relief Valves That Exceed the Capability of Testing Laboratories

Section I

Approval Date: August 30, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: If a valve design exceeds the size, capacity, or pressure capability of an ASME-accepted testing laboratory, what alternative requirements to Section I, PG-69, Capacity Certification Testing, and Section I, PG-73 or Section VIII, Division 1, UG-136, Minimum Requirements, may be followed?

Reply: It is the opinion of the Committee that if a valve design exceeds the size, capacity, or pressure capability of an ASME-accepted testing laboratory the requirements of Section I, PG-67 through PG-73 and PG-110 shall be met with the following exceptions:

(a) For Section I, PG-69

(1) If the design exceeds the laboratory pressure capability, Section I, PG-69.2.2 or PG-69.2.3 shall be followed with the exception that the valves will be tested with their disks fixed at the minimum design lift to establish the rated capacity.

(2) If the design exceeds the laboratory size or capacity capability, Section I, PG-69.2.3 shall be followed with the exception that flow models of three different sizes, each tested at three different pressures, shall be used in place of valves required in Section I, PG-69.2.3

(a). Such flow models shall be sized consistent with the capabilities of the accepted test laboratory, where the test will be conducted and shall accurately model those features that affect flow capacity, such as orifice size, valve lift, and internal flow configuration. The test models need not be functional pressure relief valves, but shall be geometrically similar to the final product.

(3) In either case of subpara. (1) or (2) above, the valve design (i.e., parameters such as spring properties, seat geometry, and mechanical valve lift) shall be evaluated to ensure that production valves will achieve design lift as modeled above.

(b) For Section I, PG-73.4.3, the requirements of either subpara. (1) or (2) below shall be met:

(1) In lieu of the test requirements of Section I, PG-73.4.3:

(-a) two production valves that are representative of the design shall be tested per PTC 25, Part III (edition adopted by the governing Code Section), to demonstrate to the satisfaction of the representative of the ASME designated organization that:

(-1) The measured set pressure is consistent with the stamped set pressure within the tolerances required by Section I, PG-72.2.

(-2) The valve will achieve the minimum lift for its certified capacity.

(-3) The valve will operate without chatter or flutter. If only one valve of the design will be produced within the six-year period within which the permission is granted, only that valve need be tested as stated above.

(-b) The testing shall be performed at a facility that is mutually agreeable to the manufacturer, the representative of an ASME-designated organization, and the facility owner. The facility shall be capable of demonstrating the characteristics stated above.

(-c) In the event of failure of the tests, the manufacturer shall submit a written explanation to the ASME designated organization stating the cause and the corrective action taken to prevent recurrence followed by a repeat of the demonstration tests.

(2) The test requirements of Section I, PG-73.4.3 are followed using two functional models that are representative of the design in lieu of the production samples and the additional following tests are satisfactorily completed:

(-a) two production valves that are representative of the design shall be tested per PTC 25, Part III (edition adopted by the governing Code Section), to demonstrate to the satisfaction of the representative at the ASME designated organization that:

(-1) The measured set pressure is consistent with the stamped set pressure within the tolerances required by Section I, PG-72.2.

(-2) Seat tightness and a secondary pressure-zone leakage test are demonstrated in accordance with Section I, PG-73.5.3.

If only one valve of the design will be produced within the six-year period within which the permission is granted, only that valve need be tested as stated above.

(-b) The testing shall be performed at a facility that is mutually agreeable to the manufacturer, the representative of an ASME-designated organization, and the facility

owner. The facility shall be capable of demonstrating the characteristics stated above.

(-c) In the event of failure of the tests, the manufacturer shall submit a written explanation to the ASME designated organization stating the cause and the corrective action taken to prevent recurrence followed by a repeat of the demonstration tests.

(-d) After initial permission is granted in accordance with Section I, PG-73.4.3, permission may be extended for six-year periods if the tests of production samples are successfully completed in accordance with subparas. (-a) through (-c) above.

(c) This Case number shall be included with the marking information required in Section I, PG-110 and on Form P-8 for the valve, as applicable.

Case 2400

Alternative Rules for the Postweld Heat Treatment of Finned Tubes

Section VIII, Division 1

Approval Date: February 14, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May electric resistance welded fins be exempt from the postweld heat treatment requirements of Table UHA-32 for P-No. 7 base materials?

Reply: It is the opinion of the Committee that it is not necessary that electric resistance welds used to attach extended heat absorbing surfaces to tubes be postweld heat treated provided the following requirements are met:

(a) The fin thickness is no greater than 0.125 in. (3.2 mm).

(b) The maximum carbon content of the base metal shall be restricted to 0.15%.

(c) The maximum outside pipe or tube diameter (excluding fins) shall be 4½ in.

(d) Postweld heat treatment is not a service requirement.

(e) Prior to using the welding procedure, the Manufacturer shall demonstrate that the heat affected zone does not encroach upon the minimum wall thickness.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2402-1

SA-995, UNS J92205, (CD3MN), Austenitic/Ferritic Duplex Stainless Steel

Section VIII, Division 1

Approval Date: September 25, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SA-995 UNS J92205 (CD3MN) solution annealed casting material be used in the construction of vessels under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The maximum allowable design stress values in tension shall be those listed in [Table 1](#) and [Table 1M](#).

NOTE: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See paras. A-340 and A-360 in Appendix A of Section II, Part D.

(b) Tensile, S_u , and yield strength, S_y , at temperature are shown in [Table 2](#), [2M](#), [3](#), and [3M](#), respectively.

(c) For Section VIII external pressure design, Figure and Table HA-5 of Section II, Part D shall be used.

(d) Separate welding procedure qualifications and performance qualifications shall be conducted as prescribed in Section IX.

(e) Heat treatment after welding is neither required nor prohibited. However, if heat treatment is applied, the solution annealing treatment shall consist of heating to a minimum temperature of 2050°F and then quenched in water or rapidly cooled by other means.

(f) The rules in Section VIII, Division 1 that shall apply are those given in Subsection C, Part UHA for austenitic-ferritic duplex stainless steels.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values In Tension For Metal Temperature of SA-995 Castings

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	25.7
150	25.7
200	25.7
250	25.2
300	24.6
400	24.3
500	24.3

Table 1M
Maximum Allowable Stress Values In Tension For Metal Temperature of SA-995 Castings

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	177
65	177
100	177
150	170
200	168
250	168
300	168 [Note (1)]

NOTE: (1) This value is provided for interpolation purposes only. The maximum temperature for this materials is 260 °C.

Table 2
Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Tensile Strength, ksi
100	90.0
200	90.0
300	86.2
400	85.2
500	85.2

Table 2M
Tensile Strength Values

For Metal Temperature Exceeding, °C	Tensile Strength, MPa
40	621
65	621
100	621
150	594
200	587
250	587
300	587

Table 3
Yield Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi
100	60.0
200	53.9
300	47.9
400	44.5
500	42.3

Table 3M
Yield Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa
40	414
65	395
100	366
150	330
200	308
250	294
300	284

Case 2403

Aluminum Alloy (Aluminum-6.3Magnesium) for Code Construction

Section VIII, Division 1

Approval Date: February 13, 2003

Impending Annulment Date: October 1, 2025

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May aluminum alloy (Aluminum-6.3Magnesium), plate, sheet, bar, rod, and wire that meet the chemical and mechanical property requirements in [Tables 1](#) and [2](#), respectively, and otherwise conforming to one of the specifications listed in [Table 3](#), be used in Section VIII, Division 1 welded construction?

Reply: It is the opinion of the Committee that aluminum alloy (Aluminum-6.3Magnesium) plate, sheet, bar, rod, and wire, as described in the Inquiry may be used in Section VIII, Division 1 welded construction provided the following additional requirements are met.

(a) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for aluminum alloys.

(b) The maximum allowable stress values for the material shall be those given in [Table 4](#).

(c) Separate welding procedure and performance qualifications shall be conducted for the material in accordance with Section IX. The minimum tensile strength and elongation for weld procedure qualification shall be that given for the base metal product form.

(d) Heat treatment after welding is not permitted.

(e) This Case is not intended for material to be used for external pressure applications.

(f) This Case number shall be shown on the documentation and marking of the material and recorded in the Manufacturer's Data Report.

CAUTION: Prolonged elevated temperature exposure above 150°F may make this material susceptible to exfoliation, intergranular attack, or stress-corrosion cracking.

**Table 1
Chemical Requirements**

Element	Composition, %
Silicon, max.	0.4
Iron, max.	0.4
Copper, max.	0.10
Manganese	0.5–0.8
Magnesium	5.8–6.8
Zinc, max.	0.20
Titanium	0.02–0.10
Beryllium	0.0002–0.005
Other elements, each	0.05
Other elements, total	0.10
Aluminum	remainder

**Table 2
Mechanical Property Requirements**

Property	Product Form		
	Sheet	Plate	Bar/Rod/ Wire
Tensile strength, min., ksi	43.5	39.5	45.0
Yield strength (0.2% offset), min., ksi	21.0	18.0	22.5
Elongation, min, %	15.0	6.0	15.0

**Table 3
Product Specifications**

Product	Specification
Plate, sheet	SB-209
Bar, rod, wire	SB-211

**Table 4
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Product Form		
	Sheet	Plate	Bar/Rod/ Wire
100	12.4	11.3	12.9

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

Case 2407

Pneumatic Test

Section VIII, Division 1

Approval Date: February 13, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use a pneumatic test in lieu of the hydrostatic test specified in ULT-99 for pressure testing of vessels constructed in accordance with the requirements of Section VIII, Division 1, Part ULT?

Reply: It is the opinion of the Committee that it is permissible to use a pneumatic test in lieu of the hydrostatic test specified in ULT-99 for pressure testing of vessels constructed in accordance with the requirements of Section VIII, Division 1, Part ULT, provided the following additional requirements are met:

(a) The vessel shall be pneumatically tested at ambient temperature for a minimum of 15 min.

(b) The pneumatic test shall be performed in accordance with UG-100, except that the ratio of stresses is not applied, and the test pressure shall be at least 1.2 times the internal design pressure at 100°F (38°C). In no case shall the pneumatic test pressure exceed 1.25 times the basis for calculated test pressure as defined in 3-2.

(c) The liquid penetrant examination required by ULT-57(b) shall be performed prior to the pneumatic test.

(d) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: The vessel should be tested in such a manner as to ensure personnel safety from a release of the stored energy of the vessel.

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Case 2411

Use of Polymer Material for Bolted Box Headers

Section IV

Approval Date: June 23, 2005

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the polymer composed of a polystyrene-modified polyphenylene ether reinforced with 30% glass fibers, be used as the material for a bolted box header in Section IV construction?

Reply: It is the opinion of the Committee that a polystyrene-modified polyphenylene ether reinforced with 30% glass fibers, by weight, may be used as the material for a bolted box header in Section IV "H" stamped construction, provided the following requirements are met:

1 GENERAL REQUIREMENTS

(a) The polymer material shall be in compliance with the ASTM material specification D4349-93 and shall be limited to the polymer with a classification designation of PPE210G30A40452G1125F11 in accordance with the ASTM D4349-93 specification. In addition, the polymer material shall be certified by the materials manufacturer, and a report of test results shall be furnished to the boiler manufacturer for each lot of material.

(b) The bolted box headers shall not be exposed to the products of combustion.

(c) The completed boiler shall be limited to hot water service.

(d) The maximum heat input to the completed boiler shall be limited to 400,000 Btu/hr (120 kW).

(e) The maximum allowable working pressure shall be limited to 30 psig (200 kPa).

(f) The maximum water temperature shall be limited to 115°F (45°C), which shall be noted in the ASME stamping and documented on the Manufacturer's Data Report.

(g) The maximum volume of the bolted box header shall be limited to 1.0 gal (3.7 L).

(h) The polymer box header shall not be repaired prior to the application of the ASME marking.

(i) The polymer box header shall have a permanently attached label stating, "No repairs are permitted to this polymer box header."

(j) The polymer box header shall be insulated from the tubesheet to which it is bolted.

(k) The polymer box header shall be permanently marked in a manner to provide traceability to the material manufacturer's report of test results and to the injection molding machine.

(l) The injection molding process shall be controlled by a written procedure in which all of the following process variables shall be considered essential:

(1) melt temperature

(-a) nozzle

(-b) front

(-c) middle

(-d) rear

(2) mold temperature

(3) drying time (average)

(4) drying time (maximum)

(5) moisture content (% maximum)

(6) back pressure

(7) screw speed

(8) shot size to cylinder size

A change in any of the essential variables shall require requalification of the written procedure per the test procedure specified below. The Authorized Inspector shall monitor compliance of the written procedure.

(m) Headers used for qualification testing shall not be used on Code stamped boilers.

(n) The use of regrind material is prohibited.

(o) This Code Case number shall be shown on the Manufacturer's Data Report.

2 DESIGN QUALIFICATION

The maximum allowable working pressure of the bolted box header shall be established by the following procedure:

(a) One or more full-scale prototype headers shall be subjected to a cyclic pressure test followed by a hydrostatic qualification test.

(b) The temperature of the test fluid for all tests shall be 115°F (45°C), minimum.

(c) The pressure shall be cycled from atmospheric to the design pressure and back 30,000 times.

(d) Then the pressure in the same prototype header shall be applied at a uniform rate so that six times the MAWP is reached in not less than 1 min.

(e) Leaks are prohibited.

Table 1
Visual Acceptance Criteria

Defects	Definitions	Maximum
Black spots, brown streaks	Dark spots or streaks	None permitted
Blisters	Hollows on or in the part	Pressure side: none permitted; None Pressure side: $\frac{1}{8}$ in. (3 mm) max. diameter, max. density 1/sq. ft (1/0.1 sq. m), none less than 2 in. (50 mm) apart
Bubbles	Air entrapped in the part	$\frac{1}{8}$ in. (3 mm) max. diameter, max. density 4/sq. in. (4/650 sq. mm); $\frac{1}{16}$ in. (1.5 mm) max. diameter, max. density 10/sq. in. (10/650 mm)
Burn marks, dieseling	Charred or dark plastic caused by trapped gas	None permitted
Cracking, crazing	Any visible	None permitted
Delamination	Single surface layers flake off the part	None permitted
Discoloration	Similar to burn marks, but generally not as dark or severe	Acceptable
Flow, halo, blush marks	Marks seen on the part due to flow of molten plastic across the molding surface	Acceptable
Gels	Bubbles or blisters on or in the part due to poor melt quality	None permitted
Jetting	Undeveloped frontal flow	None permitted

(f) The Authorized Inspector shall verify the cyclic pressure test and shall witness the hydrostatic pressure test.

(g) The prototype need not be tested to destruction.

(h) The prototype header shall be weighed to an accuracy of 0.1 oz (2.8 g). The weight shall be recorded on the Manufacturer's Data Report, Supplementary Sheet, H-6.

(i) The prototype header shall be visually examined for imperfections. Classification and acceptance level of imperfections shall be according to Table 1.

3 PRODUCTION HEADERS

(a) Each header shall be examined internally and externally for imperfections. Classification and acceptance level of imperfections shall be according to Table 1.

(b) Each production header shall be weighed within an accuracy of 0.1 oz (2.8 g), and the weight shall not be less than 98.75% of the weight of the prototype unit.

(c) The first ten headers in a production run shall be examined for conformance with dimensions and tolerances shown on the design drawings. Any dimension failing outside the specified limit shall be cause for rejection.

(d) Every tenth header after the first ten headers in a production run shall be examined for conformance with dimensions and tolerances shown on the design drawings. Any dimension failing outside the specified limits shall be cause for rejection of that header and the previous nine headers.

4 PRODUCTION QUALIFICATION

(a) At least one header per 1000 duplicate headers shall be subjected to a cyclic pressure and hydrostatic qualification pressure test per the requirements listed above.

(b) The header to be used for this test shall be selected at random by the Authorized Inspector.

Case 2416

Use of 15Cr-5Ni-3Cu (UNS S15500)

Section VIII, Division 2

Approval Date: February 13, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May martensitic precipitation hardened stainless steel 15Cr-5Ni-3Cu (UNS S15500) forgings complying with SA-705 Type XM-12 be used for pressure vessels constructed under Section VIII, Division 2?

Reply: It is the opinion of the Committee that martensitic precipitation hardened stainless steel forgings as described in the Inquiry may be used for pressure vessels constructed under Section VIII, Division 2 provided the following additional requirements are met:

- (a) The material shall be in the H1100 condition.
- (b) External pressure not permitted.
- (c) The design stress intensity and yield values shall be those listed in [Table 1](#).
- (d) No welding is permitted.
- (e) Exemption from impact testing is not permitted.

(f) This Case number shall be shown on the material certification, marking on the material, and on the Manufacturer's Data report.

Table 1
Yield Strength and Design Stress Intensity Values

For Metal Temperature Not Exceeding, °F	Yield Strength S_y , ksi	Design Stress Intensity S_m , ksi
100	115.0	46.7
200	107.1	46.7
300	103.2	46.2
400	100.5	44.7
500	98.1	43.5
600	95.4	42.4

GENERAL NOTE: Caution is advised when using this material above 550°F. After prolonged exposure above 550°F, the toughness of this material may be reduced See Appendix A, A-360 of Section II, Part D.

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Case 2418-2

SA-182, SA-240, SA-479, SA-789, SA-790, and SA-815 21Cr-5Mn-1.5Ni-Cu-N (UNS S32101) Austenitic-Ferritic Duplex Stainless Steel

Section VIII, Division 1

Approval Date: June 23, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed UNS S32101 wrought material conforming to the requirements of specifications SA-182, SA-240, SA-479, SA-789, SA-790, and SA-815, or meeting the requirements of Table 1 and mechanical properties of Table 2 and otherwise meeting the requirements of SA-182 be used in the construction of vessels under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) For SA-182, the material meets the chemical analysis and minimum mechanical properties shown in Table 1 and Table 2, respectively.

(b) The maximum allowable design stress values in tension shall be those listed in Table 3 and Table 3M. The maximum applicable use temperature shall be 600°F (316°C).

(c) For external pressure design, Figure HA-5 and Table HA-5 of Section II, Part D shall be used.

(d) This material is assigned P-No. 10H, Group 1.

(e) The solution annealing temperature shall be 1,870°F (1020°C) minimum and then quenched in water or rapidly cooled by other means.

(f) Heat treatment after welding is neither required nor prohibited. However, if heat treatment is applied, the solution annealing treatment shall be as noted in (e).

(g) The rules that shall apply are those given in Subsection C, Part UHA for austenitic-ferritic duplex stainless steels.

(h) This Case number shall be included in the marking and documentation of the material and shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Weight, %
Carbon	0.040
Manganese	4.0–6.0
Silicon, max.	1.00
Sulfur, max.	0.030
Phosphorus, max.	0.040
Chromium	21.0–22.0
Nickel	1.25–1.70
Molybdenum	0.10–0.80
Nitrogen	0.20–0.25
Copper	0.10–0.80

**Table 2
Mechanical Properties**

Mechanical Properties	$t > 0.187$ in.	$t > 5.00$ mm	$t \leq 0.187$ in.	$t \leq 5.00$ mm
Tensile Strength				
Min. ksi	94	...	101	...
Min. MPa	...	650	...	700
Yield Strength				
Min. ksi	65	...	77	...
Min. MPa	...	450	...	530
Elongation in 2 in., %	30	30	30	30

**Table 3
Maximum Allowable Stress Values, ksi**

For Metal Temperature Not Exceeding, °F	Seamless Products, $t > 0.187$ in.	Welded Products, $t > 0.187$ in.	Seamless Products, $t \leq 0.187$ in. [Note (1)]	Welded Products, $t \leq 0.187$ in. [Note (1)]
100	26.9	22.9	28.9	24.6
200	26.9	22.9	28.9	24.6
300	25.6	21.8	27.5	23.4
400	24.7	21.0	26.5	22.5
500	24.7	21.0	26.5	22.5
550	24.7	21.0	26.5	22.5
600	24.7	21.0	26.5	22.5

CAUTION: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

NOTE: (1) All SA-815 products shall only use allowable stresses listed for $t > 0.187$ in.

**Table 3M
Maximum Allowable Stress Values, MPa**

For Metal Temperature Not Exceeding, °C	Seamless Products, $t > 5.00$ mm	Welded Products, $t > 5.00$ mm	Seamless Products, $t \leq 5.00$ mm [Note (1)]	Welded Products, $t \leq 5.00$ mm [Note (1)]
40	186	158	200	170
65	186	158	200	170
90	186	158	200	170
150	177	150	190	161
200	171	145	184	156
250	170	145	183	156
300	170	145	183	156
325	170	145	183 [Note (2)]	156 [Note (2)]

CAUTION: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

NOTES:

(1) All SA-815 products shall only use allowable stresses listed for $t > 5.00$ mm.

(2) This value is provided for interpolation purposes only. The maximum design temperature for this material is as stated in (b).

Case 2419

Use of SA-268 Ferritic Stainless Steel Welded Tubing, TP430 Ti, UNS S43036

Section VIII, Division 1

Approval Date: May 21, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible in construction conforming to the rules of Section VIII, Division 1, to use welded tubing of UNS S43036 ferritic stainless steel conforming to the requirements of SA-268 Grade TP430 Ti?

Reply: It is the opinion of the Committee that the welded tubular product materials described in the Inquiry may be used in Section VIII, Division 1, construction provided the following requirements are met:

(a) The rules in Section VIII, Division 1, Subsection C, Part UHA, for ferritic stainless steel shall apply.

(b) The design temperature shall not exceed 800°F.

(c) The maximum allowable design stress values shall be those listed in [Table 1](#).

(d) For external pressure design, use Fig. CS-2 of Section II, Part D.

(e) Welding procedure and performance qualifications shall be performed in accordance with Section IX.

(f) This Case number shall be included on the Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress Values, ksi [Note (1)] and [Note (3)]
100	14.6 [Note (2)]
200	14.6 [Note (2)]
300	14.1 [Note (2)]
400	13.7 [Note (2)]
500	13.4 [Note (2)]
600	13.1 [Note (2)]
650	12.9 [Note (2)]
700	12.6 [Note (2)]
750	12.3 [Note (2)]
800	11.9 [Note (2)]

NOTES:

- (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.
- (2) These stress values include a joint efficiency factor of 0.85.
- (3) This material may be expected to develop embrittlement after service at moderately elevated temperatures.

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Case 2421

Single Fillet Lap Joint for Heat Exchanger Tube Welds

Section VIII, Division 1

Approval Date: May 21, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a Type (6), single fillet lap joint, be used for Category B joints in heat exchanger tubes in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that a Type (6) lap joint may be used for Category B joints in heat exchanger tubes provided the following requirements are met:

(a) The Type (6) joint is not allowed in heat exchangers where the tubes act as stays or for fixed-fixed tubesheets.

(b) The maximum design temperature shall not exceed 800°F (425°C).

(c) Neither cyclic loading nor tube vibration shall be a controlling design requirement. (See UG-22.)

(d) The vessel shall not be in lethal service.

(e) The joint efficiency to be used in the appropriate design equations shall be 0.45.

(f) The tube outside diameter shall not exceed 2 in. (50 mm).

(g) The nominal wall thickness of the tube shall not exceed $\frac{1}{8}$ in. (3 mm).

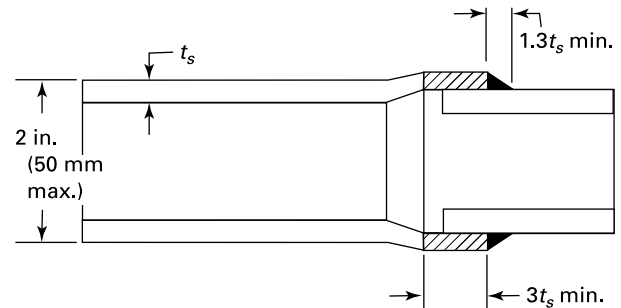
(h) The lap at the joint and the weld size shall meet the requirements of Figure 1.

(i) The joint shall have a pressed fit before welding.

(j) No tube forming is permitted at the joint after welding.

(k) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1



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Case 2426

Titanium Nickel-Molybdenum Ruthenium Alloy, Ti-0.8Ni-0.3Mo-0.1Ru

Section VIII, Division 1

Approval Date: January 27, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May a Ti-0.8Ni-0.3Mo-0.1Ru alloy identical to ASME Grade 12 (UNS R53400) with 0.1 ruthenium added for corrosion enhancement may be used in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that a Ti-0.8Ni-0.3Mo-0.1Ru alloy identical to ASME Grade 12 (UNS R53400) with 0.1 ruthenium added for corrosion enhancement may be used in Section VIII, Division 1 construction provided the following requirements are met:

(a) The material shall meet the chemical analysis shown in [Table 1](#) and all other requirements of the corresponding specifications listed in [Table 2](#).

(b) The material shall meet the minimum mechanical properties of Grade 12 in the respective specifications shown in [Table 2](#).

(c) The maximum allowable stress values shall be as shown in [Table 3](#).

(d) External pressure chart NFT-1 shall be used for the material.

(e) Separate welding procedure qualifications and welding performance qualifications conducted in accordance with the requirements of Section IX shall be required for these materials.

(f) All other rules for Section VIII, Division 1 applicable to titanium-nickel-molybdenum alloy Grade 12 (including F12, WPT12, and WPT12W) shall be met.

(g) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

**Table 1
Chemical Requirements**

Element	Composition, %
Oxygen	0.25 max.
Iron	0.30 max.
Hydrogen	0.015 max.
Carbon	0.08 max.
Nitrogen	0.03 max.
Nickel	0.6–0.9
Molybdenum	0.2–0.4
Ruthenium	0.08–0.14
Residuals, each	0.1
Residuals, total	0.4
Titanium	Remainder

**Table 2
Product Specifications**

Product	Specification	Grade
Plate, sheet, strip	SB-265	12
Bar, billet	SB-348	12
Forgings	SB-381	F12
Seamless tube	SB-338	12
Welded tube	SB-338	12
Seamless pipe	SB-861	12
Welded pipe	SB-862	12
Seamless fittings	SB-363	WPT12
Welded fittings	SB-363	WPT12W

**Table 3
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi [Note (1)]	
	Wrought	Welded Pipe and Tube [Note (2)]
–20 to 100	20.0	17.0
150	20.0	17.0
200	18.7	15.9
250	17.4	14.8
300	16.2	13.8
350	15.2	12.9
400	14.3	12.1
450	13.6	11.5
500	13.1	11.1
550	12.7	10.8
600	12.3	10.5

NOTES:

- (1) Values are identical to the values for Grade 12 in ASME Section II, Part D, Table 1B.
- (2) A joint efficiency of 85% has been used in determining the joint efficiency in welded pipe, fittings, and tube.

Case 2427

Chromium-Nickel-Molybdenum-Nitrogen-Tungsten Duplex Stainless Steel UNS S39274 Plate

Section VIII, Division 1

Approval Date: May 21, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may solution-annealed UNS S39274 plates be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the construction of welded pressure vessels conforming to the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The material meets the chemical requirement given in [Table 1](#) and the minimum mechanical property requirements given in [Table 2](#), and otherwise conforms to the requirements of SA-240.

(b) For Section VIII, Division 1 construction, the rules for austenitic-ferritic stainless steels in Subsection C, Part UHA, shall apply.

(c) The plates shall be solution annealed in the temperature range of 1920°F–2100°F (1050°C–1150°C) and shall then be quenched in water or rapidly cooled by other means.

(d) The maximum allowable stress values shall be as given in [Table 3](#). The maximum design temperature is 650°F (345°C).

(e) For external pressure design, Fig. HA-2, in Section II, Part D, shall be used.

(f) Welding procedure and performance qualifications shall be performed in accordance with Section IX.

(g) Heat treatment after forming or fabrication is neither required nor prohibited. When heat treatment is performed, it shall be performed as noted in (c).

(h) Welding shall be done using the GTAW or SMAW process.

(i) This Case number shall be included in the material documentation and marking and shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.030 max.
Manganese	1.00
Phosphorus	0.030 max.
Sulfur	0.020 max.
Silicon	0.80 max.
Nickel	6.0–8.0
Chromium	24.0–26.0
Molybdenum	2.5–3.5
Nitrogen	0.24–0.32
Copper	0.20–0.80
Tungsten	1.50–2.50

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength, min., ksi (MPa)	116	(800)
Yield strength, 0.2% offset, min., ksi (MPa)	80	(550)
Elongation in 2-in., (50 mm) gage length, min, %	15	...
Hardness, max.	310 HB or 32 HRC	...

Table 3
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi	For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa
100	33.1	40	229
200	33.1	100	228
300	31.6	150	218
400	31.4	200	216
500	31.4	250	216
600	31.4	300	216
650	31.4	350	216 [Note (1)]

GENERAL NOTES:

- (a) The revised criterion of 3.5 on tensile strength was used in establishing these values.
- (b) The material embrittles after exposure at moderately elevated temperatures. See paras. A-340 and A-360 in Appendix A of Section II, Part D.

NOTE: (1) This value is provided for interpolation purposes only. The maximum design temperature for this material is as stated in (d).

Case 2428-4

Attachment of Tubes to Flat Tubesheets Using Complete Penetration Welds

Section VIII, Division 1

Approval Date: April 17, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible to attach tubes to a flat tubesheet by welding when the tubes have partial or no penetration into the tubesheet for Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that it is permissible to attach tubes to a flat tubesheet by welding when the tubes have partial or no penetration into the tubesheet for Section VIII, Division 1 construction, provided the following requirements are met:

(a) The tube and tubesheet materials shall be restricted to P-No. 1, P-No. 3, or P-No. 4 materials.

(b) The materials shall not be used at temperatures exceeding the temperature limit for Section VIII, Division 1 shown in Section II, Part D, Subpart 1, Table 1A nor shall they be used at temperatures where the time-dependent properties govern.

(c) The weld joining the tube to the tubesheet shall be a full penetration weld made from the I.D. of the tube. (See [Figure 1](#).) The throat of the weld shall be equal to or greater than the thickness of the tube. The root pass shall be made using the GTAW process.

(d) PWHT per UCS-56 is mandatory. The exemptions to PWHT noted in Table UCS-56 shall not apply.

(e) The welding procedure specifications, the welders, and the welding operators shall be qualified in accordance with Section IX.

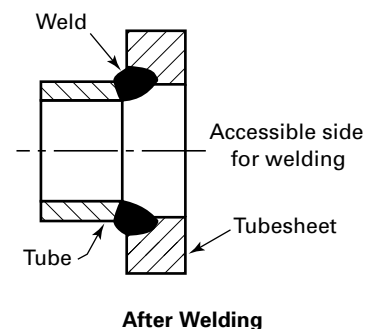
(f) In addition to meeting the performance qualification requirements of (e), before making a production weld each welder and welding operator shall demonstrate his or her ability to achieve complete weld penetration and

minimum thickness by successfully welding six test pieces. The test pieces shall be welded in a mockup of the production weld. The mockup shall be of identical position, dimensions, and materials as that of the production weld. The test pieces shall be visually examined to verify complete penetration and sectioned to verify minimum required weld thickness. The results shall be recorded and maintained with the performance qualification record.

(g) Each weld surface on the tube I.D. shall receive either a magnetic particle or liquid penetrant examination in accordance with Section VIII, Division 1, Mandatory Appendix 6 or Mandatory Appendix 8, as applicable. In addition, a visual examination of the weld surface on the tube O.D. shall be performed. The maximum practicable number of these welds, but in no case fewer than 50%, shall be visually examined. Visual examination shall show complete penetration of the joint root and freedom from cracks.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Full Penetration Weld



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Case 2430

Use of A213/A213M-04 UNS S31060 Austenitic Stainless Steel Seamless Tubing and A240/A240M-04a^{ε1} UNS S31060 Austenitic Stainless Steel Plate

Section I; Section VIII, Division 1

Approval Date: January 12, 2005

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may A213/A213M-04a UNS S31060 austenitic stainless steel seamless tubes and A240/A240M-04a^{ε1} UNS S31060 austenitic stainless steel plates be used in steam service under the rules of Section I and in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in steam service under the rules of Section I and in welded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The grain size of UNS S31060 shall conform to an average grain size of ASTM No. 7 or coarser, as measured by Test Methods E112.

(b) For Section I construction, the rules of PG-19 for 304N shall apply for this material, except that solution treatment, when required, shall be in the range of 1,975°F to 2,160°F (1 080°C to 1 180°C); and the y coefficient shall be that for austenitic materials in Note (6) of PG-27.4.

(c) For Section VIII, Division 1 construction, the rules for austenitic stainless steels in Subsection C, Part UHA shall apply. The rules of UHA-44 for 304N shall apply

for this material, except that solution treatment, when required, shall be in the range of 1,975°F to 2,160°F (1 080°C to 1 180°C).

(d) The maximum allowable stress values shall be as given in [Tables 1](#) and [1M](#). The maximum design temperature is 1,740°F (950°C).

(e) For external pressure design, [Figures 1](#) and [1M](#) and [Table 2](#) shall be used.

(f) Separate welding procedure and performance qualifications shall be performed in accordance with Section IX.

(g) For a design temperature above 1,500°F (815°C), filler metals shall be limited to those having a composition similar to that of the base material, except having an aim chemistry including 1% Mo, 0.04% (Ce + La), and 0.3% N.

(h) When welding is performed with filler metal of similar composition as the base metal [see [\(g\)](#)] welding processes shall be limited to the GTAW and SMAW welding processes.

(i) Post-weld heat treatment is neither required nor prohibited. When heat treatment is performed, the material shall be solution treated in the range of 1,975°F to 2,160°F (1 080°C to 1 180°C).

(j) This Case number shall be included in the material documentation and marking and shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi	Allowable Stress Values, ksi
-20 to 100	24.9	24.9
200	24.2	24.2
300	22.9	22.9
400	22.0	22.3 [Note (1)]
500	21.3	22.0 [Note (1)]
600	20.7	21.8 [Note (1)]
650	20.5	21.7 [Note (1)]
700	20.2	21.6 [Note (1)]
750	20.0	21.4 [Note (1)]
800	19.8	21.2 [Note (1)]
850	19.6	20.9 [Note (1)]
900	19.5	20.5 [Note (1)]
950	19.3	20.1 [Note (1)]
1,000	19.2	19.5 [Note (1)]
1,050	18.8	18.8
1,100	15.3	15.3
1,150	12.2	12.2
1,200	9.4	9.4
1,250	7.1	7.1
1,300	5.4	5.4
1,350	4.0	4.0
1,400	3.1	3.1
1,450	2.4	2.4
1,500	1.9	1.9
1,550	1.5	1.5
1,600	1.3	1.3
1,650	1.0	1.0
1,700	0.87	0.87
1,750	0.74 [Note (2)]	0.74 Note (2)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only.

Table 1M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa	Allowable Stress Values, MPa
-30 to 100	171	171
65	171	171
100	166	166
125	161	161
150	158	158
175	155	156 [Note (1)]
200	152	154 [Note (1)]
225	150	153 [Note (1)]
250	157	152 [Note (1)]
275	145	151 [Note (1)]
300	144	151 [Note (1)]
325	142	150 [Note (1)]
350	141	150 [Note (1)]
375	139	149 [Note (1)]
400	138	148 [Note (1)]
425	137	146 [Note (1)]
450	136	145 [Note (1)]
475	134	142 [Note (1)]
500	134	140 [Note (1)]
525	133	136 [Note (1)]
550	132	132
575	121	121
600	100	100
625	81.5	81.5
650	64.2	64.2
675	50.0	50.0
700	38.7	38.7
725	29.9	29.9
750	23.4	23.4
775	18.5	18.5
800	14.8	14.8
825	12.2	12.1
850	10.0	10.0
875	8.4	8.4
900	7.1	7.1
925	6.1	6.1
950	5.2	5.2

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Figure 1
Chart for Determining Shell Thickness of Components under External Pressure When Constructed of Alloy UNS S31060

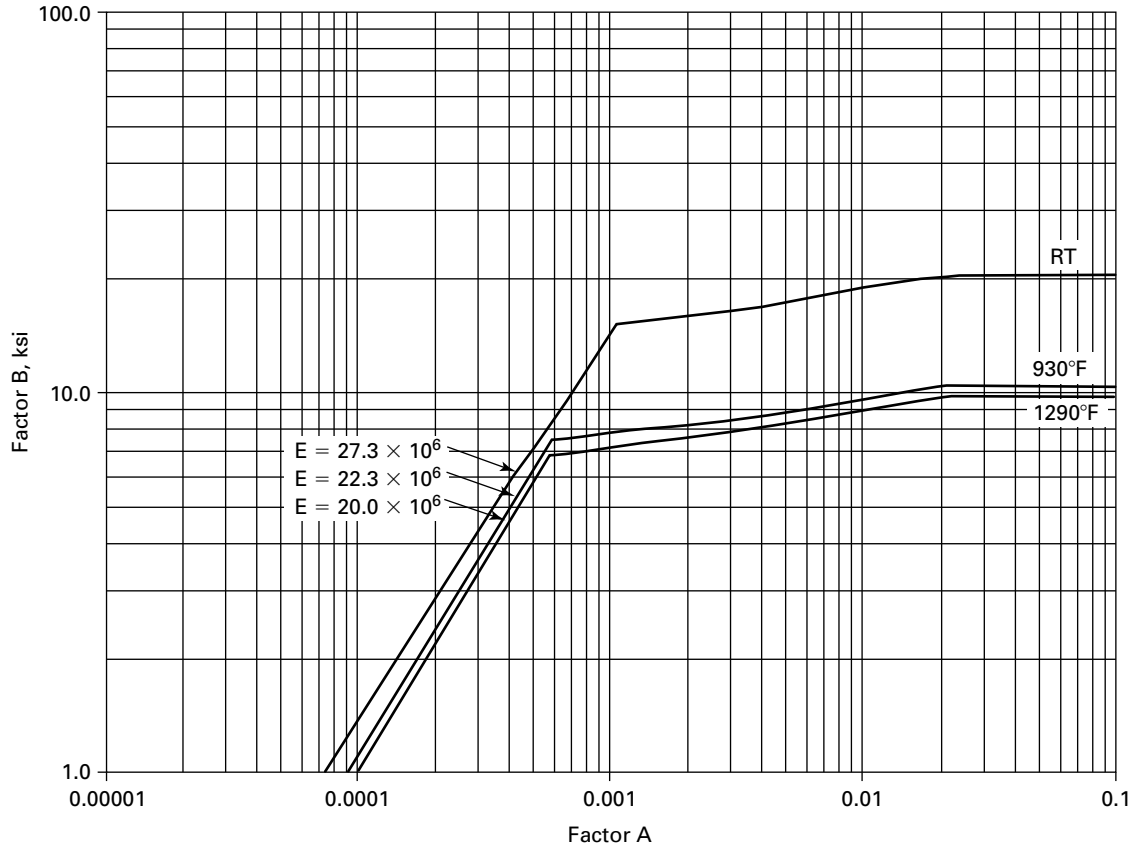


Figure 1M
Chart for Determining Shell Thickness of Components under External Pressure When Constructed of Alloy UNS S31060

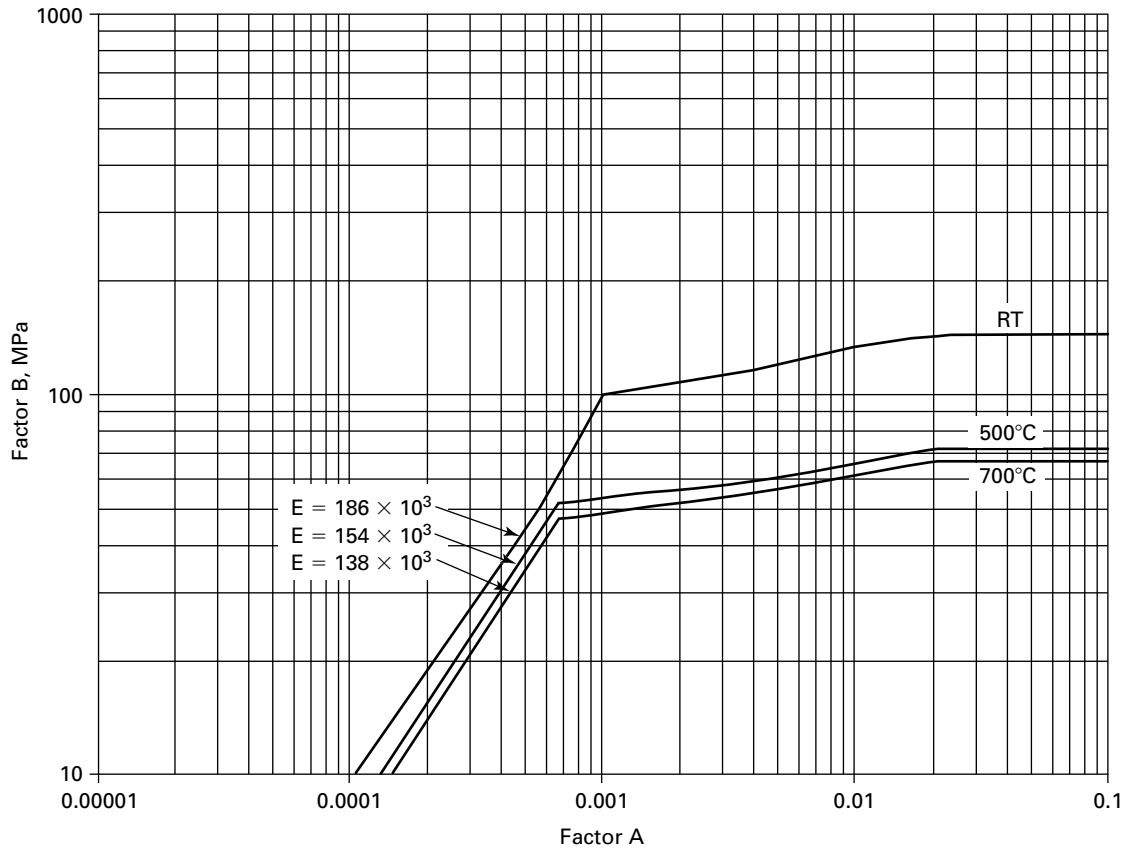


Table 2
Tabular Values for UNS S31060

Temp., °F	Temp., °C	A	B, ksi	B, MPa
RT	RT	7.33-05	1.0	6.9
		1.06-03	14.5	100.0
		3.00	16.0	110.3
		4.50	17.0	117.2
		6.85	18.0	124.1
		1.00-02	19.0	131.0
		1.75	20.0	137.9
		2.52	20.5	141.3
		1.00-01	20.5	141.3
930	500	8.97-05	1.0	6.9
		6.82-04	7.6	52.4
		1.50-03	8.0	55.2
		3.30	8.5	58.6
		5.70	9.0	62.1
		9.40	9.5	65.5
		1.50-02	10.0	69.0
		2.10	10.5	72.1
		1.00-01	10.5	72.1
1,290	700	1.00-04	1.0	6.9
		6.80	6.8	46.9
		1.80-03	7.5	51.7
		6.20	8.5	58.6
		9.90	9.0	62.1
		2.05-02	9.75	67.2
		1.00-01	9.75	67.2

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Case 2432-1

Use of 5052-H32, 6061-T6, and 6061-T651 Temper Aluminum Alloys in Part HF of Section IV, for Construction of Heating Boilers

Section IV; Section II, Part B

Approval Date: June 20, 2008

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May aluminum alloys, 5052-H32, 5052-O, 6061-T6, and 6061-T651 be used in the construction of Section IV hot water heating boilers?

Reply: It is the opinion of the committee that 5052-H32, 5052-O, 6061-T6, and 6061-T651 aluminum alloys may be used for the construction of Section IV hot water heating boilers provided the following conditions are met:

(a) Materials shall conform to the specifications listed in [Table 1](#) for the various product forms.

(b) The minimum allowable thickness shall be the same as that shown in Table HF-301.2 for copper, admiralty, and red brass.

(c) Maximum metal temperature shall not exceed 300°F (150°C).

(d) Maximum allowable stress values shall be as shown in [Table 2](#), [Table 2M](#), [Table 3](#), and [Table 3M](#).

(e) All other requirements of Section IV shall apply.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Product Specifications

Product Form	Specification Number	UNS Number
Sheet and plate	SB-209	A95052/A96061
Drawn seamless tube	SB-210	A95052/A96061
Bar, rod, and wire	SB-211	A96061
Extruded bar, rod, and shape	SB-221	A96061
Seamless pipe and seamless extruded tube	SB-241/SB-241M	A95052/A96061

Table 2
Maximum Allowable Stress Values for Welded 5052 Aluminum

Specification Number	Temper	Specified Min. Tensile Strength, ksi	Specified Min. Yield Strength, ksi	Allowable Stress Values, ksi for Metal Temperature Not Exceeding, °F				
				-20 to 100	150	200	250	300
Sheet and Plate								
SB-209	H32 welded	25	9.5	5.0	5.0	5.0	4.7	4.5
Drawn Seamless Tube								
SB-210	H32 welded	25	10	5.0	5.0	5.0	4.7	4.5
Seamless Pipe and Seamless Extruded Tube								
SB-241/SB-241M	H32 welded	25	10	5.0	5.0	5.0	4.7	4.5
Drawn Seamless Tube								
SB-210	O brazed	25	10	5.0	5.0	5.0	4.7	4.5

Table 2M
Maximum Allowable Stress Values for Welded 5052 Aluminum

Specification Number	Temper	Specified Min. Tensile Strength, MPa	Specified Min. Yield Strength, MPa	Allowable Stress Values, MPa for Metal Temperature Not Exceeding, °C				
				-30 to 40	65	100	125	150
Sheet and Plate								
SB-209	H32 welded	172	69	34.5	34.5	34.5	34.5	32.8
Drawn Seamless Tube								
SB-210	H32 welded	172	69	34.5	34.5	34.5	34.5	32.8
Seamless Pipe and Seamless Extruded Tube								
SB-241/SB-241M	H32 welded	172	69	34.5	34.5	34.5	34.5	32.8
Drawn Seamless Tube								
SB-210	O brazed	172	69	34.5	34.5	34.5	34.5	32.8

Table 3
Maximum Allowable Stress Values for Welded 6061-T6 And 6061-T651 Aluminum

Specification Number	Temper	Specified Min. Tensile Strength, ksi	Specified Min. Yield Strength, ksi	Allowable Stress Values, ksi for Metal Temperature Not Exceeding, °F				
				-20 to 100	150	200	250	300
Sheet and Plate								
SB-209	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
	T651 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
Drawn Seamless Tube								
SB-210	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
Bar, Rod, Wire								
SB-211	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
...	T651 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
Extruded Bar, Rod, and Shapes								
SB-221	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
Seamless Pipe and Seamless Extruded Tube								
SB-241/SB-241M	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4

Table 3M
Maximum Allowable Stress Values for Welded 6061-T6 And 6061-T651 Aluminum

Specification Number	Temper	Specified Min. Tensile Strength, MPa	Specified Min. Yield Strength, MPa	Allowable Stress Values, MPa for Metal Temperature Not Exceeding, °C				
				-30 to 40	65	100	125	150
Sheet and Plate								
SB-209	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2
	T651 welded	165	55	33.1	33.1	33.1	32.6	31.2
Drawn Seamless Tube								
SB-210	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2
Bar, Rod, Wire								
SB-211	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2
	T651 welded	165	55	33.1	33.1	33.1	32.6	31.2
Extruded Bar, Rod, and Shapes								
SB-221	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2
Seamless Pipe and Seamless Extruded Tube								
SB-241/SB-241M	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2

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Case 2439

Ni-Cr-Co-Mo Alloy (UNS N06617)

Section I

Approval Date: February 14, 2003

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed Ni-Cr-Co-Mo alloy (UNS N06617) wrought plate, rod, bar, forgings, and seamless tube that meet the requirements of the specifications listed in [Table 1](#) be used in water wetted service in welded construction under Section I?

Reply: It is the opinion of the Committee that solution annealed Ni-Cr-Co-Mo alloy (UNS N06617) as described in the Inquiry may be used in the construction of welded pressure vessels under Section I, provided the following additional requirements are met.

(a) Material shall be solution annealed at a temperature of 2100–2250°F and quenched in water or rapidly cooled by other means.

(b) The materials shall conform to the specifications listed in [Table 1](#).

(c) The maximum allowable stress values for the material shall be those given in [Table 2](#).

(d) For welding, P-No. 43 shall be applied for procedure qualifications and performance qualifications in accordance with Section IX.

(e) Heat treatment after forming or fabrication is neither required nor prohibited.

When heat treatment is performed, it shall be in accordance with [\(a\)](#) above. For parameter y [see PG-27.4, Note (6)], the y values shall be as follows:

1,050°F and below	$y = 0.4$
1,200°F	$y = 0.5$

This Case number shall be shown in the documentation and marking of the material.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe under deposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Product Specifications

Product	Specifications
Forgings	SB-564
Plate and sheet	SB-168
Rod and bar	SB-166
Tube	SB-167

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi [Note (1)]
100	23.3, ...
200	20.5, 23.3 [Note (2)]
300	19.1, 23.3 [Note (2)]
400	18.1, 23.3 [Note (2)]
500	17.3, 23.3 [Note (2)]
600	16.7, 22.5 [Note (2)]
700	16.2, 21.9 [Note (2)]
800	15.9, 21.5 [Note (2)]
900	15.7, 21.1 [Note (2)]
1,000	15.5, 20.9 [Note (2)]
1,100	15.4, 20.7 [Note (2)]
1,150	15.4, 20.7 [Note (2)]
1,200	15.3, 16.9 [Note (2)]

NOTES:

- (1) The revised criterion of 3.5 on tensile strength was used in establishing these values.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Case 2440-1

Use of Mn- $\frac{1}{2}$ Mo- $\frac{1}{2}$ Ni (UNS K12039) Pipe

(25)

Section I

Approval Date: November 10, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS K12039 seamless pipe material, conforming to the chemical and mechanical properties of SA-302 C but meeting all the other requirements of SA-335, be used in the manufacture of Section I boilers?

Reply: It is the opinion of the Committee that UNS K12039, as described in the Inquiry, may be used for the manufacture of Section I boilers provided the following requirements are met:

(a) The material shall meet the chemical composition and mechanical property requirements of [Table 1](#) and [Table 2](#) of this Case and otherwise conform to applicable requirements in Specification SA-335.

(b) Material shall be supplied in the normalized condition.

(c) The design temperature shall not exceed 1000°F (540°C).

(d) The maximum allowable stress values shall be those listed in [Table 3](#) and [Table 3M](#).

(e) This material shall be treated as P-No. 3, Group 3.

(f) This Case number shall be shown on the material certification and marking of the material and on the Manufacturer's Data Report.

**Table 1
Chemical Requirements**

Element	Composition, %
Carbon, max.	
Up to 1 in. (25 mm) incl. in thickness	0.20
Over 1 to 2 in. (50 mm), incl.	0.23
Over 2 in. (50 mm) in thickness	0.25
Manganese	
heat analysis	1.15–1.50
product analysis	1.07–1.62
Phosphorous, max. [Note (1)]	0.035
Sulfur, max. [Note (1)]	0.035
Silicon	
heat analysis	0.15–0.40
product analysis	0.13–0.45
Molybdenum	
heat analysis	0.45–0.60
product analysis	0.41–0.64
Nickel	
heat analysis	0.40–0.70
product analysis	0.37–0.73

NOTE: (1) Value applies to both heat and product analyses.

**Table 2
Mechanical Property Requirements**

Tensile strength, ksi (MPa)	80–100 (550–690)
Yield strength, min, ksi (MPa)	50 (345)
Elongation in 2 in., min., %	20

**Table 3
Maximum Allowable Stress Values
(U.S. Customary Units)**

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress (ksi)
–20 to 100	22.9
200	22.9
300	22.9
400	22.9
500	22.9
600	22.9
700	22.9
800	22.9
850	20.0 [Note (1)]
900	13.7 [Note (1)]
950	8.2 [Note (1)]
1,000	4.8 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

**Table 3M
Maximum Allowable Stress Values
(Metric Units)**

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress (MPa)
–30 to 40	158
65	158
425	158
450	143
475	106 [Note (1)]
500	68.4 [Note (1)]
525	43.0 [Note (1)]
550	23.1 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

Case 2445-2

23Cr-25Ni-5.5Mo-N, UNS S32053, Austenitic-Stainless Steel

Section VIII, Division 1

Approval Date: June 25, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 23Cr-25Ni-5.5Mo-N, UNS S32053, austenitic stainless steel sheet, strip, plate, pipe, tube, and bar, meeting the chemical composition and mechanical property requirements shown in Tables 1 and 2, and otherwise conforming to one of the specifications given in Table 3, be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section VIII, Division 1 construction, provided the following additional requirements are met:

(a) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UHA for austenitic stainless steels.

(b) For external pressure design, use Fig. NFN-12 in Section II, Part D.

(c) The maximum allowable stress values for the material shall be those given in Tables 4 and 4M. For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

(d) Maximum design temperature of the material shall be 662°F (350°C).

(e) Separate welding procedure and performance qualifications shall be conducted for the material in accordance with Section IX.

(f) Heat treatment after forming or fabrication is neither required nor prohibited.

(g) The material shall be furnished in the solution annealed condition at a temperature range from 1,967°F (1080°C) to 2,156°F (1180°C) followed by rapid cooling in air or water.

(h) This Case number shall be shown on the documentation and marking of the material and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon, max.	0.030
Manganese, max.	1.00
Phosphorus, max.	0.030
Sulfur, max.	0.010
Silicon, max.	1.00
Chromium	22.00–24.00
Nickel	24.00–26.00
Molybdenum	5.00–6.00
Nitrogen	0.17–0.22
Iron	Balance

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength, min. (ksi)	93 [640 MPa]
Yield strength, 0.2% offset, min. (ksi)	43 [295 MPa]
Elongation in 2 in., or 4D, min. (%)	40

Table 3
Product Specifications

Bars and shapes	SA-479
Bolting materials	SA-193
Flanges, fittings, and valves	SA-182
Nuts for bolts	SA-194
Piping fittings	SA-403
Seamless and welded pipes	SA-312
Sheet, strip, and plate	SA-240
Welded tubes	SA-249
Welded pipes	SA-358
Welded pipes	SA-409
Welded pipes	SA-813
Welded pipes	SA-814

Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding,	
°F	Allowable Stress Values, Max., ksi
100	26.5, 26.5
200	24.2, 26.5 [Note (1)]
300	21.9, 25.1 [Note (1)]
400	20.8, 23.9 [Note (1)]
500	19.3, 23.0 [Note (1)]
600	18.5, 22.3 [Note (1)]
650	18.2, 22.0 [Note (1)]
700	17.9, 21.8 [Note (1)], [Note (2)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only. The maximum use temperature is 662°F.

Table 4M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding,	
°C	Allowable Stress Values, Max., MPa
40	183, 183
65	177, 183 [Note (1)]
100	164, 182 Note (1)]
150	151, 173 Note (1)]
200	141, 165 Note (1)]
250	134, 160 Note (1)]
300	129, 155 Note (1)]
325	127, 153 Note (1)]
350	125, 152 Note (1)], [Note (2)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only. The maximum use temperature is 350°C.

Case 2446-1

Pilot-Operated Pressure Relief Valves for PG-67.2.1.6 Applications

(25)

Section I

Approval Date: November 10, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a pilot-operated pressure relief valve be used to satisfy the requirements of PG-67.2.1.6?

Reply: It is the opinion of the Committee that a pilot-operated pressure relief valve may be used to satisfy the requirements of PG-67.2.1.6, provided all of the following conditions are met:

(a) all requirements of PG-67 through PG-73 inclusive, as applicable for economizer overpressure protection.

(b) the pilot-operated pressure relief valve must be self-actuated and the main valve will open automatically at not over the set pressure and will discharge its full rated capacity if some essential part of the pilot should fail.

(c) the pilot-operated pressure relief valve shall be capacity certified for steam service per PG-69.

(d) the pilot-operated pressure relief valve shall be capacity certified for water service to the test requirements of PG-69.1 with the following exceptions:

(1) Set pressure and blowdown adjustment tests shall be performed using steam in accordance with PG-69.1.

(2) If the four-device method of Section XIII, 9.7.5 is used for incompressible fluids, the absolute flow-rating pressure P_f shall have a maximum pressure for capacity certification test of 103% of set pressure, or set pressure + 15 kPa (2 psi), whichever is greater.

(3) If the coefficient of discharge method of Section XIII, 9.7.6 is used for water or other incompressible fluids, the absolute relieving pressure P shall have a maximum pressure for capacity certification test of 103% of set pressure, or set pressure + 15 kPa (2 psi), whichever is greater.

(e) the nameplate shall be marked in accordance with PG-110. The set pressure shall be based on steam tests. In addition to the steam capacity in lbm/hr (kg/h), the nameplate shall be marked with water capacity in gal/min (L/min) at 70°F (20°C).

(f) this Case number shall be on a plate permanently attached to the valve.

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Case 2458-3

Austenitic Fe-27Ni-22Cr-7Mo-Mn-Cu-N Alloy (UNS S31277)

Section I; Section VIII, Division 1

Approval Date: January 22, 2007

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May annealed austenitic Fe-27Ni-22Cr-7Mo-Mn-Cu-N Alloy (UNS S31277) wrought sheet, strip, plate, rod and bar, flanges and fittings, and seamless and welded pipe and tubing with chemical analysis shown in [Table 1](#) and minimum mechanical properties shown in [Table 2](#) and otherwise conforming to one of the specifications shown in [Table 3](#), be used in welded construction under the rules of Section I for water wetted and steam service?

Reply: It is the opinion of the Committee that material described in the inquiry may be used in Section I construction at a design temperature of 800°F (427°C) or less, provided the following additional requirements are met:

(a) The maximum allowable stress values for material shall be those given in [Tables 4](#) and [4M](#). The maximum design temperature shall be 800°F (427°C). For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

(b) The material shall be considered as P-No. 45.

(c) Heat treatment during or after fabrication is neither required nor prohibited.

(d) For external pressure design, use [Figures 1](#) and [1M](#) and [Tables 5](#) and [5M](#).

(e) This Case number shall be shown on the documentation and marking of the material and recorded in the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Chemical Composition

Element	Composition, %
Carbon, max.	0.020
Manganese, max.	3.00
Phosphorus, max.	0.030
Sulfur, max.	0.010
Silicon, max.	0.50
Nickel	26.0–28.0
Chromium	20.5–23.0
Molybdenum	6.5–8.0
Copper	0.50–1.50
Nitrogen	0.30–0.40
Iron [Note (1)]	Balance

NOTE: (1) This element shall be determined arithmetically by difference.

Table 2
Mechanical Property Requirements (All Product Forms)

Tensile strength, min.	112 ksi (770 MPa)
Yield strength, 0.2% offset, min.	52 ksi (360 MPa)
Elongation in 2 in. or 4D, min.	40%

Table 3
Product Specifications

Flanges and fittings	SA-182
Plate, sheet, and strip	SA-240
Rod and bar	SA-479
Seamless and welded pipe	SA-312
Seamless tubing	SA-213
Welded tubing	SA-249

Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F		Allowable Stress Values, Max., ksi
100	32.0, 32.0	
150	32.0, 32.0	
200	32.0, 32.0	
250	30.4, 31.5 [Note (1)]	
300	28.8, 30.7 [Note (1)]	
350	27.5, 30.0 [Note (1)]	
400	26.5, 29.4 [Note (1)]	
450	25.9, 28.4 [Note (1)]	
500	25.5, 28.4 [Note (1)]	
550	25.4, 27.9 [Note (1)]	
600	25.4, 27.5 [Note (1)]	
650	25.4, 27.1 [Note (1)]	
700	25.3, 26.8 [Note (1)]	
750	25.1, 26.5 [Note (1)]	
800	24.9, 26.3 [Note (1)]	

GENERAL NOTE: The revised criteria of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 4M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C		Allowable Stress Values, Max., MPa
40	220, 220	
65	220, 220	
100	218, 220 [Note (1)]	
150	198, 212 [Note (1)]	
200	184, 203 [Note (1)]	
250	177, 197 [Note (1)]	
300	175, 191 [Note (1)]	
325	175, 189 [Note (1)]	
350	175, 186 [Note (1)]	
375	175, 185 [Note (1)]	
400	173, 183 [Note (1)]	
425	172, 181 [Note (1)]	
450	172, 182 [Note (1)], [Note (2)]	

GENERAL NOTE: The revised criteria of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) The maximum use temperature is 427°C, the value listed at 450°C is provided for interpolation purposes only.

Table 5
Tabular Values for UNS S31277

Temp., °F	A		Temp., °F	B, ksi		
	A	B, ksi		A	B, ksi	
Up to 100	1.00 -05	0.139	600	1.00 -05	0.126	
	7.21	1.0		7.92	1.0	
	1.37 -03	19.0		9.50 -04	12.0	
	2.00	20.0		2.00 -03	14.0	
	5.00	22.0		4.50	16.0	
	1.10 -02	24.0		1.20 -02	18.0	
	2.40	26.0		2.10	19.0	
	1.00 -01	26.0		1.00 -01	19.0	
	200	0.136		800	1.00 -05	0.121
	7.38	1.0			8.27	1.0
1.22 -03	16.6	9.27 -04	11.3			
2.10	18.0	1.70 -03	13.0			
4.70	20.0	3.50	15.0			
2.10 -02	24.1	8.50	17.0			
1.00 -01	24.1	2.00 -02	18.7			
400	0.131	1.00 -01	18.7			
7.63	1.0					
9.92 -04	13.0					
2.20 -03	15.0					
5.50	17.0					
8.90 -03	18.0					
2.10 -02	19.8					
1.00 -01	19.8					

Table 5M
Tabular Values for UNS S31277

Temp., °C	A		Temp., °C	B, MPa		
	A	B, MPa		A	B, MPa	
Up to 38	1.00 -05	0.958	315	1.00 -05	0.869	
	1.04 -04	10.0		1.15 -04	10.0	
	1.37 -03	131.0		9.50	82.7	
	2.00	137.9		2.00 -03	96.5	
	5.00	151.7		4.50	110.3	
	1.10 -02	165.5		1.20 -02	124.1	
	2.40	179.3		2.10	131.0	
	1.00 -01	179.3		1.00 -01	131.0	
	95	0.938		425	1.00 -05	0.834
	1.07 -04	10.0			1.20 -04	10.0
1.22 -03	114.5	9.27	77.6			
2.10	124.1	1.70 -03	89.6			
4.70	137.9	3.50	103.4			
2.10 -02	166.2	8.50	117.2			
1.00 -01	166.2	2.00 -02	128.9			
205	0.903	1.00 -01	128.9			
1.11 -04	10.0					
9.92	89.6					
2.20 -03	103.4					
5.50	117.2					
8.90 -03	124.1					
2.10 -02	136.5					
1.00 -01	136.5					

Figure 1
Chart for Determining Shell Thickness of Components Under External Pressure When Constructed of Alloy UNS S31277

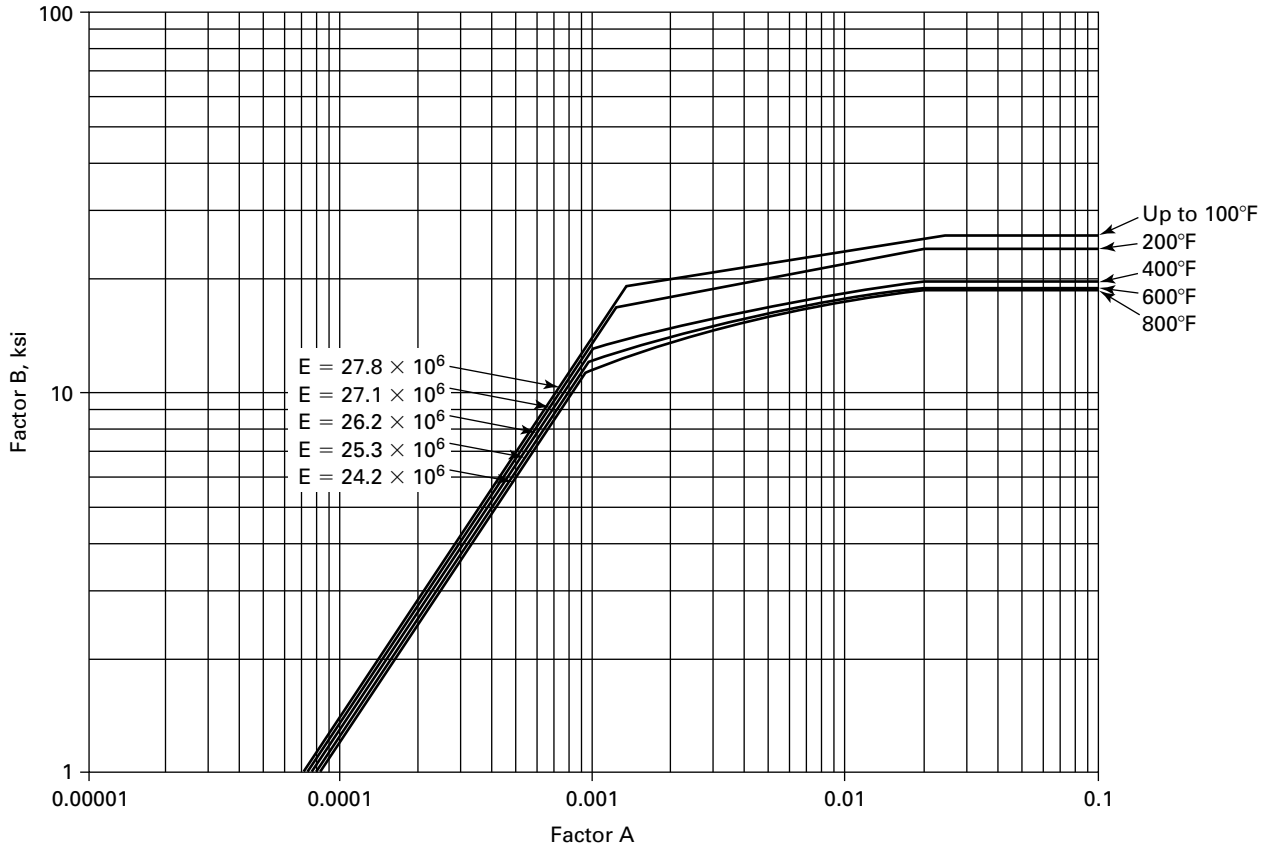
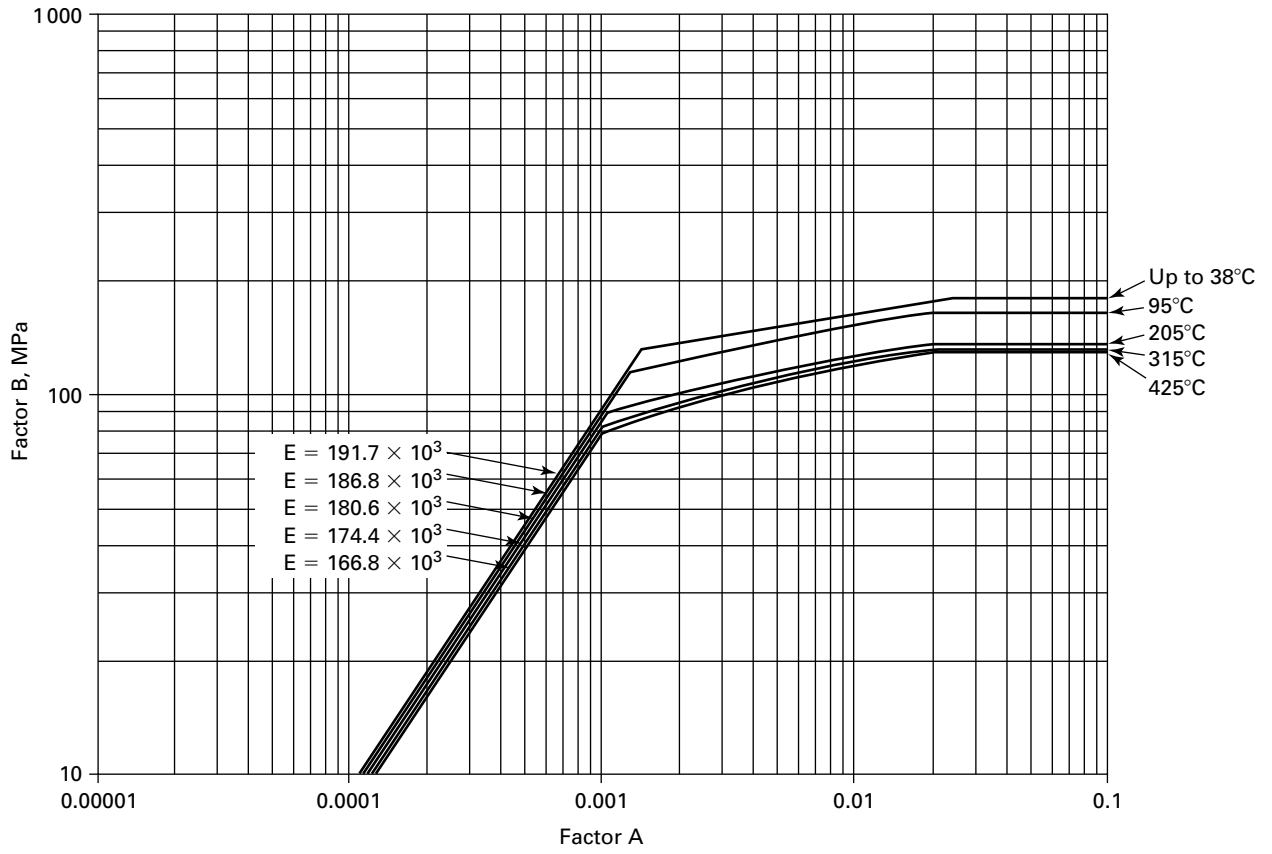


Figure 1M
Chart for Determining Shell Thickness of Components Under External Pressure When Constructed of Alloy UNS S31277



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Case 2461-2

Use of Chromium-Silicon Alloy Steel Wire for Pressure Vessel Winding

Section VIII, Division 3

Approval Date: September 12, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May a flat hardened and tempered chromium-silicon alloy steel wire be used for winding of Section VIII, Division 3 pressure vessels constructed to the requirements of KD-9 and KF-9?

Reply: It is the opinion of the Committee that flat hardened and tempered chromium-silicon alloy steel wire may be used for winding of Section VIII, Division 3 pressure vessels, provided the wire conforms to SA-905 with the following exceptions:

(a) Materials and Manufacture

(1) The steel may be made by any commercially accepted steel making process. The steel shall be continuously cast.

(2) The finished wire shall be free from detrimental pipe and undue segregation.

(b) Chemical Analysis

(1) The steel shall conform to the requirements for chemical composition specified in [Table 1](#).

(2) *Heat Analysis.* Each heat of steel shall be analyzed by the manufacturer to determine the percentage of elements prescribed in [Table 1](#). This analysis shall be made from a test specimen preferably taken during the pouring of the heat. When requested, this shall be reported to the purchaser and shall conform to the requirements of [Table 1](#).

(3) *Product Analysis.* An analysis may be made by the purchaser from finished wire representing each heat of steel. The average of all the separate determinations made shall be within the limits specified in the analysis column. Individual determinations may vary to the extent shown in the product analysis tolerance column, except that several determinations of a single element in any one heat shall not vary both above and below the specified range.

(4) For reference purposes, A751, Test Methods, Practices, and Terminology, shall be used.

(c) Metallurgical Requirements

(1) Decarburization

(-a) Transverse sections of the wire properly mounted, polished, and etched shall show no completely decarburized (carbon-free) areas when examined using 100× magnification. Partial decarburization shall not exceed a depth of 0.001 in. (0.025 mm).

(-b) Number of Tests. One test specimen shall be taken for each of five coils, or fraction thereof, in a lot.

(-c) Location of Tests. Test specimens may be taken from either end of the coil.

(2) Inclusion Content

(-a) The inclusion content of the wire rod in the worst case shall not exceed the limits shown in [Table 2](#) as described in Test Method E45, Plate I-r, Method D, except that alternate methodologies are acceptable upon agreement between the purchaser and supplier, provided minimum requirements are not lower than those of Test Method E45, Method D.

(-b) If any coil exceeds the limits in [Table 2](#), all coils in the lot will be inspected. Each coil that fails to meet the requirements will be rejected.

(-c) Number of Tests. One test specimen shall be taken for each group of 10 coils, or fraction thereof, in the lot.

(-d) Location of Tests. Test specimens may be taken from either end of the coil.

(-e) Test Method. Examination shall be made in accordance with Test Method E45.

(d) Final heat treatment shall consist of austenitizing, quenching, and tempering to achieve the required mechanical properties.

(e) Mechanical properties shall meet the properties given in [Table 3](#).

(f) The nondestructive examination according to Supplementary Requirement S1 of SA-905 is mandatory.

(g) Yield strength values provided in [Tables 4](#) and [4M](#) shall be used for design.

(h) The design temperature shall not exceed 300°F (150°C). The designer is cautioned that stress relaxation might occur at design conditions permitted by this Code Case.

(i) This Case number shall be shown on the marking and certification of the material and on the Manufacturer's Data Report.

**Table 1
Chemical Requirements**

Element	Heat Analysis, %	Product Analysis Tolerance, %
Carbon	0.51-0.59	±0.02
Manganese	0.50-0.80	±0.03
Phosphorus	0.025 max.	±0.005
Sulfur	0.025 max.	±0.005
Silicon	1.20-1.60	±0.05
Chromium	0.60-0.80	±0.03

**Table 2
Maximum Inclusion Content**

Zone [Note (1)]	Inclusion Type							
	A		B		C		D	
	Thin	Heavy	Thin	Heavy	Thin	Heavy	Thin	Heavy
Surface	1	1	1	1/2	1	1	1	1/2
Core	2	1 1/2	2	1	2	1 1/2	2	1

NOTE: (1) The *surface zone* is from the wire surface to 1/3 radius deep. The *core* is the balance.

**Table 3
Tensile Requirements**

Thickness, in. (mm)	Tensile Strength min., ksi (MPa)	Yield Strength min., ksi (MPa)	Elongation min., %
0.04-0.06 (1.0-1.5)	297 (2050)	261 (1800)	4.0

**Table 4
Design Data for Yield Strength**

Thickness, in.	Yield Strength, ksi for Metal Temperature Not Exceeding		
	100°F	200°F	300°F
0.04-0.06	261	254	230

**Table 4M
Design Data for Yield Strength**

Thickness, mm	Yield Strength, MPa for Metal Temperature Not Exceeding				
	40°C	65°C	100°C	125°C	150°C
1.0-1.5	1800	1800	1740	1670	1580

Case 2463-1

Welding of Tubes to Tubesheets by Deformation Resistance Welding (DRW) Process

Section VIII, Division 1

Approval Date: September 8, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Deformation Resistance Welding (DRW) is a resistance welding process in which coalescence of mating components is accomplished by heating them together in a resistance weld machine and facilitating their relative movement at the weld interface, while deforming them. The resulting joint is primarily a solid-state weld while some melting and solidification of the mating parts may also occur. May the DRW process be used to weld tubes to tubesheets for Section VIII, Division 1 construction if impact testing of the tube-to-tubesheet joint is not required?

Reply:

(a) It is the opinion of the Committee that it is permissible to use the DRW process to weld tubes to tubesheets for Section VIII, Division 1 construction, if impact testing of the tube-to-tubesheet joint is not required, provided the following requirements are met.

(b) This Case number shall be shown on the Manufacturer's Data Report.

1 TEST AND EXAMINATIONS

1.1 WELD SAMPLE

A demonstration qualification mockup assembly, consisting of ten mockup welds, shall be prepared and examined in accordance with Section IX, QW-193.1.

1.2 WELDING

Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs) shall address the requirements specified in 2.1. The requirements of Section IX, QW-288, as well as the additional requirements specified in 2.1 shall apply. The original Welder/Welding Operator Performance Qualifications shall be performed in accordance with QW-303.5, with the renewal being performed per 2.2.

1.3 SHEAR LOAD TEST

The tensile strength of the weld shall be at least equal to the tube strength as verified by shear load testing tensile test specimens in accordance with para. A-3, Shear Load Test, of Section VIII, Division 1, Appendix A.

2 WELD SAMPLE

2.1 ESSENTIAL VARIABLES

In addition to the applicable requirements in Section IX, QW-288, the following essential variables shall apply for the WPS and PQR:

(a) a change in the method of preparing the base metal prior to welding (e.g., changing from mechanical cleaning to chemical or to abrasive cleaning or vice versa)

(b) a change in the specified tube fold diameter by more than $0.25t$ from the nominal value, when tubes are prefolded prior to welding (see Figure 1)

(c) a change of more than 15% in the extension of the tube above the surface of the tubesheet when tubes are not prefolded prior to welding (see Figure 1)

(d) a change in the tubesheet counterbore diameter by more than 3% (see Figure 1)

(e) a change in the tubesheet counterbore depth by more than 5% (see Figure 1)

(f) an increase in tubesheet thickness by more than 20%

(g) change from one RWMA (Resistance Welding Manufacturer's Association) class electrode material to another

(h) a change of more than 5% in the electrode pressure, weld current, or the weld time from those qualified

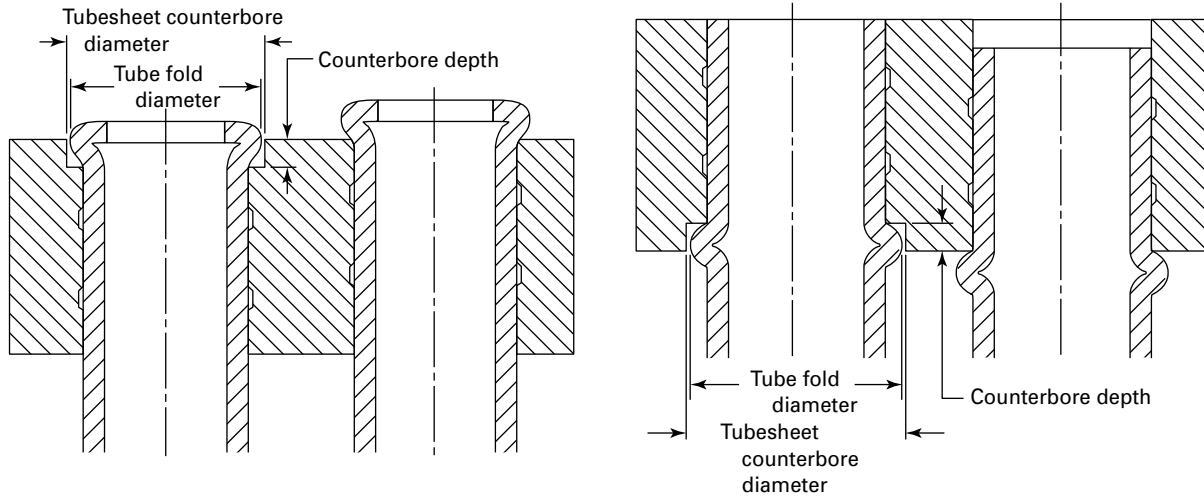
(i) a change of more than 5% in the pulse width from that qualified

(j) any change in the number of weld pulses from that qualified

(k) a change in cool time between pulses by more than 5%

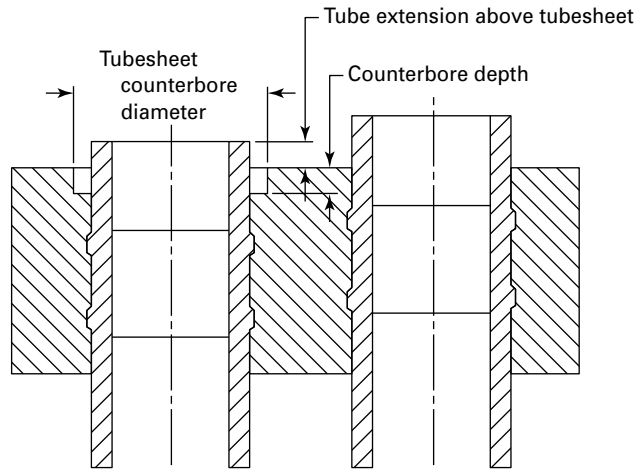
(l) addition or deletion of upslope or downslope current control or a change of more than 10% in the slope current time or amplitude

Figure 1
Typical Tube-to-Tubesheet Configurations Prior to Welding



(a) DRW Welding on Front Side of Tubesheet With or Without Tubesheet Counterbore

(b) DRW Welding on Rear Side of Tubesheet With or Without Counterbore



(c) DRW Welding on Front Side of Tubesheet With or Without Tubesheet Counterbore

GENERAL NOTE: These figures show the configuration prior to welding.

2.2 RENEWAL OF WELDING OPERATOR PERFORMANCE QUALIFICATIONS

Only the mockup weld per the tests in para. 1 is required to renew a welding operator's performance qualification per the requirements of Section IX, QW-322.1.

3 PRODUCTION TEST MONITORING

3.1 GENERAL

Production test monitoring is required to ensure the quality and repeatability of the DRW process. If there is a change in the WPS, welding machine, or operator, a new production test shall be performed.

(a) Either one push-out test or one metallographic test shall be performed at the beginning and end of each shift.

(b) Production welds made during a shift shall be considered acceptable if the tests at the beginning and end of the shift pass.

3.2 PUSH-OUT TEST

The push-out tests shall be performed as follows on test coupons containing at least one tube:

(a) Cut the tube flush with the surface of the coupon opposite the weld.

(b) Apply a uniform load to the cut surface of the tube using suitable equipment and any required jigs and fixtures to hold the test coupon. The load shall be at least 1.5 times the strength of the tube (specified

minimum tensile strength divided by the nominal cross-sectional area of the tube).

(c) The test is acceptable provided the tube is not expelled from the test assembly.

3.3 METALLOGRAPHIC TEST

The metallographic tests shall be performed as follows on test coupons containing at least one tube:

(a) Make a cut on the tube-to-tubesheet coupon along the length of the tube at its centerline.

(b) Grind or polish one of the two sections to reveal two weld interfaces approximately 180 deg apart.

(c) Etch the weld section with a suitable etchant to reveal the bond length.

(d) Visually examine the test coupon at a minimum of 10× magnification to verify there is complete bonding for a distance at least equal to the minimum required bond length.

3.4 REJECTION CRITERIA AND CORRECTIVE ACTION

(a) If the production test fails at the beginning of a shift, a new production test shall be performed. Production welding shall not commence until a successful production test is achieved.

(b) If the production test fails at the end of a shift, all the welds made during the shift shall be rejected. All rejected tube welds shall be repaired using an arc welding procedure qualified in accordance with Section IX.

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Case 2468-3

Use of Nickel-Chromium-Molybdenum-Columbium Alloy UNS N06625 for Class 2

Section VIII, Division 2

Approval Date: March 13, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS N06625 SB-443, Grade 1 (annealed) and Grade 2 (solution annealed) plate, sheet, and strip, SB-444 Grade 1 (annealed) and Grade 2 (solution annealed) pipe and tube, SB-446 Grade 1 (annealed) and Grade 2 (solution annealed) rod and bar, and SB-564 be used in Section VIII, Division 2, Class 2?

Reply: It is the opinion of the Committee that UNS N06625 SB-443 Grade 1 (annealed) and Grade 2 (solution annealed) plate, sheet, and strip, SB-444 Grade 1 (annealed) and Grade 2 (solution annealed) pipe and

tube, SB-446 Grade 1 (annealed) and Grade 2 (solution annealed) rod and bar, and SB-564 may be used for welded construction in Section VIII, Division 2, Class 2, provided the following additional requirements are met:

(a) The allowable stress values, S , shall be those listed in [Tables 1](#) and [1M](#). The maximum use temperature is 800°F (427°C) for both Grade 1 (annealed) and Grade 2 (solution annealed).

(b) For external pressure design, the following requirements shall apply:

(1) The requirements of Section II, Part D, Figure NFN-17 shall be applied for Grade 1 (annealed) material.

(2) The requirements of Section II, Part D, Figure NFN-22 shall be applied for Grade 2 (solution annealed) material.

(c) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Allowable Stress Values, S

For Metal Temperatures Not Exceeding °F	Allowable Stress Values for SB-443 Gr. 1 Annealed Material, ksi	Allowable Stress Values for SB-444 Gr. 1 Annealed Material, ksi	Allowable Stress Values for SB-446 Gr. 1 Annealed and SB-564 Material Up to 4 in. incl., ksi	Allowable Stress Values for SB-446 Gr. 1 Annealed and SB-564 Material Over 4 in. to 10 in. incl., ksi	Allowable Stress Values for SB-443 Gr. 2 Solution Annealed Material, ksi	Allowable Stress Values for SB-444 Gr. 2 Solution Annealed Material, ksi	Allowable Stress Values for SB-446 Gr. 2 Solution Annealed Material, ksi
100	36.7	40.0	40.0	33.3	26.7	26.7	26.7
200	35.3	38.5	38.5	32.1	24.6	24.6	24.6
300	34.3	37.4	37.4	31.2	23.4	23.4	23.4
400	33.3	36.3	36.3	30.3	22.5	22.5	22.5
500	32.4	35.3	35.3	29.4	21.7	21.7	21.7
600	31.5	34.4	34.4	28.6	21.0	21.0	21.0
650	31.1	33.9	33.9	28.3	20.8	20.8	20.8
700	30.7	33.5	33.5	27.9	20.5	20.5	20.5
750	30.4	33.2	33.2	27.6	20.3	20.3	20.3
800	30.1	32.9	32.9	27.4	20.1	20.1	20.1

GENERAL NOTE: Allowable stresses for Grade 2 materials are conservatively taken from Section II, Part D, Table 1B as specified for Section VIII, Division 1 use.

Table 1M
Allowable Stress Values, S

For Metal Temperatures Not Exceeding °C	Allowable Stress Values for SB-443 Gr. 1 Annealed Material, MPa	Allowable Stress Values for SB-444 Gr. 1 Annealed Material, MPa	Allowable Stress Values for SB-446 Gr. 1 Annealed and SB-564 Material Up to 100 mm incl., MPa	Allowable Stress Values for SB-446 Gr. 1 Annealed and SB-564 Material Over 100mm to 250mm incl., MPa	Allowable Stress Values for SB-443 Gr. 2 Solution Annealed Material, MPa	Allowable Stress Values for SB-444 Gr. 2 Solution Annealed Material, MPa	Allowable Stress Values for SB-446 Gr. 2 Solution Annealed Material, MPa
40	253	276	276	230	184	184	184
65	247	270	270	225	175	175	175
100	243	265	265	221	169	169	169
125	239	261	261	218	165	165	165
150	236	258	258	215	161	161	161
175	233	254	254	212	158	158	158
200	230	251	251	209	155	155	155
225	227	248	248	206	153	153	153
250	224	245	245	204	150	150	150
275	221	242	242	201	148	148	148
300	219	239	239	199	146	146	146
325	216	236	236	197	145	145	145
350	214	233	233	194	143	143	143
375	212	231	231	192	141	141	141
400	210	229	229	191	140	140	140
425	208	227	227	189	139	139	139
450 [Note (1)]	206	225	225	187	138	138	138

GENERAL NOTE: Allowable stresses for Grade 2 materials are conservatively taken from Section II, Part D, Table 1B as specified for Section VIII, Division 1 use.

NOTE: (1) This value is for interpolation purposes only. The maximum design temperature is 427°C.

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Case 2469-1

Pneumatic Testing

Section IV

Approval Date: October 21, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may heating boilers manufactured and stamped in accordance with Section IV be tested pneumatically in lieu of the hydrostatic test required in HG-510(c)?

Reply: It is the opinion of the Committee that pneumatic testing may be substituted for the hydrostatic test required in HG-510(c), provided the following requirements are met:

(a) The water volume of the boiler shall be less than 70 gals (265 L).

(b) Maximum material thickness of any component part shall not exceed $\frac{1}{2}$ in. (12.7 mm). No components of the pressure vessel that will be subject to pneumatic testing may be constructed of cast iron.

(c) The MAWP shall not be greater than 160 psi (1100 kPa).

(d) The boiler shall be externally cleaned to prevent air bubble adherence while being tested to prevent leaks from being masked.

(e) The pneumatic test shall be conducted with the boiler submerged in water. Minimum water temperature shall be 60°F (16°C). The upper most portion of the boiler, as oriented in the test tank, shall be a minimum of 6 in. (150 mm) below the surface of the water.

(f) The required test pressure shall be greater of 38 psi (262 kPa) or $1\frac{1}{4}$ times the MAWP.

(g) The pressure in the boiler shall be gradually increased to not more than one-half of the required test pressure. Thereafter, the pressure shall be increased in steps of approximately one-tenth of the required test pressure until the required test pressure has been reached.

(h) A hold time of 5 min shall be maintained on the boiler at the required test pressure. Thorough visual inspection is not required during this stage. The pressure shall then be reduced to its maximum MAWP and maintained at this pressure while a thorough visual inspection for leakage is made with the boiler submerged under water.

(i) The boiler shall meet all other requirements of Section IV.

(j) This Code Case number shall be shown on the Manufacturer's Data Report.

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Case 2473-2

F-Number Grouping for Cr-Fe-Ni-Mo-Cu, Classification UNS R20033 Filler Metal

Section I; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX

This Case number shall be shown in the Manufacturer's Data Report.

Approval Date: December 18, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternate rules may be applied to grouping UNS R20033 Cr-Fe-Ni-Mo-Cu welding filler metal meeting the chemical requirements of [Table 1](#), but otherwise conforming to AWS A5.9 to reduce the number of welding procedures and performance qualifications?

Reply: It is the opinion of the Committee that UNS R20033 Cr-Fe-Ni-Mo-Cu welding filler metal meeting the requirements of [Table 1](#), but otherwise conforming to AWS A5.9 may be considered as F-No. 45 for both procedure and performance qualification purposes. Further, this material shall be identified as UNS R20033 in the Welding Procedure Specification, Procedure Qualification Record, and Performance Qualification Records.

Table 1
Chemical Requirements (UNS R20033)

Element	Composition, %
Carbon, max.	0.015
Chromium	31.0-35.0
Nickel	30.0-33.0
Molybdenum	0.050-2.0
Manganese, max.	2.0
Silicon, max.	0.50
Phosphorus, max.	0.02
Sulfur, max.	0.01
Nitrogen	0.35-0.60
Copper	0.30-1.2
Iron	Balance
Other Elements	0.5 max.

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Case 2475

18Cr-9Ni-2.5W-V-Cb Austenitic Seamless Tube Steel

Section I

Approval Date: November 29, 2004

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-treated 18Cr-9Ni-2.5W-V-Cb austenitic stainless seamless tube steel with chemical analysis shown in [Table 1](#), the mechanical properties shown in [Table 2](#), and that otherwise conform to applicable requirements in specification SA-213 be used for steam service in Section I construction?

Reply: It is the opinion of the Committee that the material listed in the Inquiry may be used for steam service in Section I construction, provided the following requirements are met:

(a) The material shall meet the chemical analysis and minimum tensile requirements described in the Inquiry and shall otherwise meet the requirements of SA-213 as applicable, except as shown in paras. (b) and (c).

(b) The minimum solution treating temperature for this material shall be 2000°F (1100°C).

(c) This material shall have a hardness not exceeding 219 HB/230 HV (95 HRB).

(d) The rules of PG-19 for TP347H shall apply for this material, except that solution treatment, when required, shall be at the minimum temperature of 2000°F (1100°C).

(e) The maximum allowable stress values for the material shall be as given in [Tables 3](#) and [3M](#). The maximum design temperature is 1427°F (775°C).

(f) Separate welding procedures and performance qualification shall be conducted for the material in accordance with Section IX.

(g) Welding processes shall be limited to GTAW and SMAW.

(h) This Case number shall be referenced in the documentation and marking of the material and recorded on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon, max.	0.05
Manganese, max.	2.00
Phosphorus, max.	0.040
Sulfur, max.	0.030
Silicon, max.	1.00
Nickel	8.00–11.0
Chromium	17.0–20.0
Columbium	0.25–0.50
Nitrogen	0.10–0.25
Tungsten	1.50–2.60
Vanadium	0.20–0.50

Table 2
Mechanical Property Requirements

Tensile strength, min. ksi (MPa)	90 (620)
Yield strength, min. ksi (MPa)	38 (260)
Elongation in 2 in. or 50 mm, min. %	30

Table 3
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi	Allowable Stress Values, ksi
-20 to 100	25.3	25.3
200	20.0	24.9 [Note (1)]
300	17.9	23.5 [Note (1)]
400	16.6	22.4 [Note (1)]
500	15.7	21.1 [Note (1)]
600	15.0	20.2 [Note (1)]
650	14.7	19.8 [Note (1)]
700	14.4	19.4 [Note (1)]
750	14.1	19.1 [Note (1)]
800	13.9	18.7 [Note (1)]
850	13.7	18.5 [Note (1)]
900	13.5	18.2 [Note (1)]
950	13.3	18.0 [Note (1)]
1000	13.2	17.9 [Note (1)]
1050	13.2	17.8 [Note (1)]
1100	13.2	17.8 [Note (1)]
1150	13.2	15.6 [Note (1)]
1200	11.9	11.9
1250	9.1	9.1
1300	6.9	6.9
1350	5.3	5.3
1400	4.0	4.0
1450	3.1 [Note (2)]	3.1 [Note (2)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only.

Table 3M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa	Allowable Stress Values, MPa
-30 to 40	175	175
65	149	175 [Note (1)]
100	136	170 [Note (1)]
125	129	165 [Note (1)]
150	123	162 [Note (1)]
175	118	159 [Note (1)]
200	115	155 [Note (1)]
225	112	151 [Note (1)]
250	109	147 [Note (1)]
275	107	144 [Note (1)]
300	104	141 [Note (1)]
325	103	138 [Note (1)]
350	101	136 [Note (1)]
375	98.9	134 [Note (1)]
400	97.3	131 [Note (1)]
425	95.8	129 [Note (1)]
450	94.5	128 [Note (1)]
475	93.3	126 [Note (1)]
500	92.3	125 [Note (1)]
525	91.6	124 [Note (1)]
550	91.1	123 [Note (1)]
575	90.9	123 [Note (1)]
600	90.8	123 [Note (1)]
625	90.8	103 [Note (1)]
650	80.8	80.8
675	63.3	63.3
700	49.7	49.7
725	38.9	38.9
750	30.5	30.5
775	23.9	23.9

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Case 2478-1

Use of SB-247, 6061-T6 Aluminum Alloy for Class 2¹

Section VIII, Division 2

Approval Date: March 13, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SB-247, 6061-T6 aluminum alloy be used in construction of Section VIII, Division 2, Class 2 welded pressure vessels at temperatures not exceeding 300°F (150°C)?

Reply: It is the opinion of the Committee that SB-247, 6061-T6 aluminum alloy may be used in construction of Section VIII, Division 2, Class 2 welded pressure vessels at temperatures not exceeding 300°F (150°C), provided the following requirements are met:

(a) Fabrication shall conform to the applicable requirements of Section VIII, Division 2, Class 2 for aluminum alloys.

(b) Allowable stress values given in Table 1 shall be used.

(c) Yield strength values given in Section II, Part D, Table Y-1 and tensile strength values given in Section II, Part D, Table U shall be used.

(d) The chart in Figure NFA-12 in Section II, Part D, Subpart 3 (Article D-3) shall be used for external pressure design for temperatures at or below the maximum temperature for which allowable stress values are listed in Table 1. Tabular values are given in Table NFA-12 in Section II, Part D, Subpart 3.

(e) The fatigue design curves shown in Figure 1 shall be used for fatigue evaluation. Tabular values are given in Table 2. The stress amplitude, S_a , shall be reduced to one-half the values given in Figure 1 and Table 2 within 1.0 in. (25 mm) of a weld.

(f) Fatigue design shall be in accordance with the rules of Section VIII, Division 2, 5.5 using the fatigue design curves shown in Figure 1. The fatigue curve shall be corrected for temperature as described in Section VIII, Division 2, 3-F.1.1. The design fatigue curve with zero mean stress may be used if mean stress is zero or compressive.

(g) Postweld heat treatment is not permitted.

(h) When the User Design Specification stipulates more than 10,000 cycles, the value used instead of S_y for evaluating thermal ratcheting in the ratcheting rules of Section VIII, Division 2, 5.5.6.3 shall be 14 ksi (96.5 MPa) for base metal and 7 ksi (48.3 MPa) within 1.0 in. (25 mm) of a weld.

(i) Simplified elastic-plastic analysis rules of 5.5.6.2 are not applicable. The 3S limit on the range of primary plus secondary equivalent stress of 5.5.6.1(d) shall not be exceeded.

(j) All other requirements of Section VIII, Division 2 construction, as applicable, shall be met.

(k) This Case number shall be identified on the applicable Data Report Form furnished by the U2 Certificate Holder.

¹This reinstated Case has been revised.

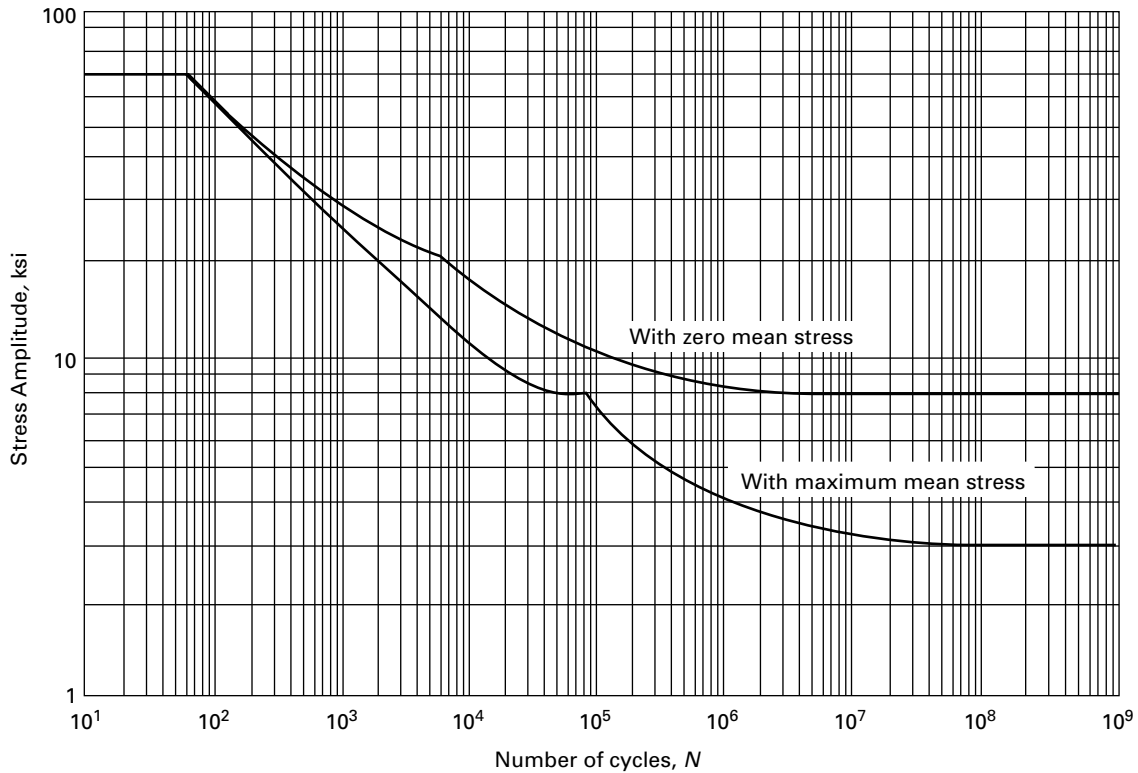
Table 1
Allowable Stress Values, S

Specification No.	Temper	Size or Thickness, in.	Specified Min. Tensile Strength, ksi	Specified Min. Yield Strength, ksi	Notes	Allowable Stress Values, ksi for Metal Temperature not Exceeding, °F				
						100	150	200	250	300
Die and Hand Forgings										
SB-247	Die T6	Up to 4.000	38	35	(1),(2)	12.7	12.7	12.7	12.1	10.5
	Hand T6	Up to 4.000	37	33	(1),(2)	12.3	12.3	12.3	11.7	10.3
	Hand T6	4.000-8.000	35	32	(1),(2)	11.7	11.7	11.7	11.2	9.9
	T6 wld.	Up to 8.000	24	...	(1)	8.0	8.0	8.0	7.9	7.3

NOTES:

- (1) Allowable stress values for 100°F may be used at temperatures down to -452°F without additional specification requirements.
- (2) The stress values given for this material are not applicable when either welding or thermal cutting is employed.

Figure 1
Design Fatigue Curve for 6061-T6 Aluminum for Temperatures Not Exceeding 300°F



GENERAL NOTE:

$$E = 10.0 \times 10^6 \text{ psi}$$

Table 2
Tabulated Values of S_a , ksi, from Figure 1

Number of Cycles [Note (1)]	Zero Mean Stress	Maximum Mean Stress
1.0E1	70.00	70.00
2.0E1	70.00	70.00
5.0E1	70.00	70.00
7.0E1	70.00	70.00
1.0E2	60.96	60.96
2.0E2	47.20	47.20
5.0E2	35.00	34.80
1.0E3	28.85	26.79
2.0E3	24.50	20.00
5.0E3	20.64	13.78
7.0E3	19.70	12.40
1.0E4	17.50	10.93
2.0E4	14.43	9.14
5.0E4	11.70	7.74
9.0E4	10.53	7.18
1.0E5	10.32	6.89
2.0E5	9.35	5.47
5.0E5	8.49	4.36
1.0E6	8.05	3.87
2.0E6	7.74	3.55
5.0E6	7.47	3.29
1.0E7	7.33	3.16
2.0E7	7.24	3.07
5.0E7	7.15	3.00
1.0E8	7.11	2.96
2.0E8	7.07	2.93
5.0E8	7.05	2.91
1.0E9	7.03	2.90

GENERAL NOTE: Interpolation between tabular values is permissible based upon data representation by straight lines on a log-log plot. See Table 1.9.1, Note (2).

NOTE: (1) The number of cycles indicated shall be read as follows:
 IEJ = 1×10^J , e.g., 5E6 = 5×10^6 or 5,000,000

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Case 2481-1

Ni-29Cr-3.5Fe-3.3Al-1.5Nb Alloy (UNS N06693)

Section VIII, Division 1

Approval Date: November 17, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May annealed austenitic Ni-29Cr-3.5Fe-3.3Al-1.5Nb Alloy (UNS N06693) wrought sheet, strip, plate, rod and bar, and seamless pipe and tubing with chemical analysis shown in Table 1 and minimum mechanical properties shown in Table 2 and otherwise conforming to one of the specifications shown in Table 3 be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that material described in the Inquiry may be used in Section VIII, Division 1 construction at a design temperature of 1,200°F (649°C) or less, provided the following additional requirements are met:

(a) The maximum allowable stress values for material shall be those given in Tables 4 and 4M. The maximum design temperature shall be 1,200°F (649°C). For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

(b) Separate welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(c) Heat treatment during or after fabrication is neither required nor prohibited. For Section VIII applications, all other requirements in Part UNF for nickel alloys shall be required.

(d) This Case number shall be shown on the documentation and marking of the material and recorded in the Manufacturer's Data Report.

Table 1
Chemical Composition

Element	Composition, %
Carbon, max.	0.15
Manganese, max.	1.0
Sulfur, max.	0.01
Silicon, max.	0.5
Nickel [Note (1)]	Balance
Chromium	27.0–31.0
Copper, max.	0.5
Iron	2.5–6.0
Aluminum	2.5–4.0
Titanium, max.	1.0
Niobium	0.5–2.5

NOTE: (1) This element shall be determined arithmetically by difference.

Table 2
Mechanical Property Requirements (All Product Forms)

Tensile strength, min., ksi (MPa)	85 (586)
Yield Strength, min., ksi (MPa)	40 (276)
Elongation in 2 in., or 4D min., %	30.0

Table 3
Product Specifications

Fittings	SB-462, SB-366
Forgings	SB-564
Plate, sheet, and strip	SB-168
Rod, bar and wire	SB-166
Seamless pipe and tube	SB-167
Welded pipe	SB-517
Welded tube	SB-516

Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi
75	24.3	24.3
100	24.3	24.3
150	24.3	24.3
200	24.3	24.3
250	24.3	24.3
300	24.3	24.3
350	24.3	24.3
400	24.3	24.3
450	24.3	24.3
500	24.2	24.3 [Note (1)]
550	24.0	24.2 [Note (1)]
600	23.8	23.9 [Note (1)]
650	23.5	23.7 [Note (1)]
700	23.4	23.4
750	23.2	23.2
800	23.0	23.0
850	23.0	23.0
900	23.0	23.0
950	23.0	23.0
1,000	23.0	23.0
1,050	17.5	17.5 [Note (2)]
1,100	12.3	12.3 [Note (2)]
1,150	8.3	8.3 [Note (2)]
1,200	5.6	5.6 [Note (2)]

GENERAL NOTES:

- (a) The revised criterion of 3.5 on tensile strength was used in establishing these values.
- (b) The alloy in the solution-annealed condition is subject to severe loss of rupture ductility in the approximate temperature range of 1,112°F to 1,200°F.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These high stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These are time-dependent values.

Table 4M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa
21	167.4	167.4
40	167.4	167.4
65	167.4	167.4
100	167.4	167.4
125	167.4	167.4
150	167.4	167.4
175	167.4	167.4
200	167.4	167.4
225	167.4	167.4
250	167.2	167.4 [Note (1)]
275	166.0	167.4 [Note (1)]
300	164.6	166.3 [Note (1)]
325	163.3	164.4 [Note (1)]
350	162.0	162.6 [Note (1)]
375	160.9	161.0 [Note (1)]
400	159.7	159.7
425	158.8	158.8
450	158.3	158.3
475	158.2	158.2
500	158.4	158.4
525	158.7	158.7
550	143.9	143.9
575	107.5	107.5
600	77.0	77.0 [Note (2)]
625	53.8	53.8 [Note (2)]
650	37.8	37.8 [Note (2)], [Note (3)]

GENERAL NOTES:

- (a) The revised criterion of 3.5 on tensile strength was used in establishing these values.
- (b) The alloy in the solution-annealed condition is subject to severe loss of rupture ductility in the approximate temperature range of 600°C to 650°C.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These high stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These are time-dependent values.
- (3) The maximum use temperature is 649°C, the value listed at 650°C is provided for interpolation purposes, only.

Case 2489

Use of SA-508 Class 1, Grades 2 and 3 Forgings

Section I

Approval Date: February 22, 2005

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-508 Class 1, Grades 2 and 3 forgings be used in the manufacture of Section I boilers?

Reply: It is the opinion of the Committee that SA-508 Class 1, Grades 2 and 3 forgings may be used in the manufacture of Section I boilers, provided the following requirements are met:

(a) The design temperature shall not exceed 800°F (427°C).

(b) The maximum allowable stress value shall be 22.9 ksi (158 MPa) at all temperatures from -20°F to 800°F (-29°C to 427°C).¹

(c) For external pressure design, use Fig. CS-5 of Section II, Part D to a maximum temperature of 650°F (343°C). For temperatures higher than 650°F (343°C), use Fig. CS-2 of Section II, Part D.

(d) This Case number shall be shown on the material certification and marking of the material and on the Manufacturer's Data Report.

¹The revised criterion of 3.5 on tensile strength was used in establishing the maximum allowable stress value.

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Case 2493-1

Parallel Plate Explosion Welding for Butt Joints Between Dissimilar Metals

Section VIII, Division 1; Section VIII, Division 2; Section IX

Approval Date: September 12, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the Parallel Plate Explosion Welding Process (with or without interlayers) be used to weld dissimilar metal plate and sheet to produce butt joint transitions for cryogenic systems, which can then be welded by conventional processes to adjacent similar metals, be qualified under the rules of Section IX?

Reply: It is the opinion of the Committee that butt joints between dissimilar metal plate and sheet produced by Parallel Plate Explosion Welding (with or without interlayers) used to produce butt joint transitions for cryogenic systems may be qualified under the rules of Section IX, provided the joints meet the applicable requirements of Section IX, the specific ASME or other Design Code where they will be utilized, and the following requirements:

1 GENERAL REQUIREMENTS

(a) The welds shall be produced between parallel flat plates in the horizontal position in normal air atmosphere.

(b) The prime, interlayer, if used, and backer component materials shall meet the requirements of appropriate ASME SA- or SB- specifications. The backer component may consist of previous explosion welded plates for multilayer requirements.

(c) Where multilayer welded plates are produced, mechanical test specimens shall be taken from the finished multilayer welded plate with a single test representing all welds.

(d) Weld repairs to the explosion weld are prohibited. Weld repair of surface blemishes or defects that do not extend to nor affect the explosion weld is permissible. Procedures and welders shall be qualified in accordance with Section IX.

(e) Fabricators shall satisfy themselves through appropriate testing that subsequent heat treatment applied to completed weldments that include explosion welded tran-

sitions does not adversely affect the explosion weld properties.

(f) Finished transition components shall meet all other applicable requirements of the ASME Process Piping or Pressure Vessel Code for which they will be used.

2 WELDING PROCEDURE QUALIFICATION

(a) The prime, interlayer, and backer materials shall be the same type and grade as the material to be welded in production (type and grade are materials of the same nominal chemical analysis and mechanical property range, even though of different product form).

(b) The arrangement of components, explosive, and other essential welding parameters listed in 5 shall be the same as will be used in production.

(c) The welding procedure shall be qualified in the same facility as the production welding.

(d) The welded plate shall be 100% ultrasonic inspected in accordance with 6.

(e) A minimum of one longitudinal bend sample in accordance with para. 7(a) shall be taken from each corner of the qualification test plate (4 tests total).

(f) A minimum of one tensile test in accordance para. 7(b) shall be taken from each corner of the qualification test plate (4 tests total).

(g) When impact testing is required by other Code sections or other standards, a minimum of three Charpy V-notch tests for each weld and each test temperature shall be taken from representative material from the qualification plate and tested in accordance with para. 7(c) (3 tests for each weld at each test temperature).

(h) Remaining material from a successful procedure qualification plate welded by a qualified operator may be used for production requirements.

3 WELDING OPERATOR PERFORMANCE QUALIFICATION

(a) The prime, interlayer(s), and backer materials shall be the same type and grade as the material to be welded in production.

(b) The arrangement of components, explosive, and other essential welding parameters listed in 5 shall be the same as will be used in production.

(c) The welding operator shall be qualified in the same facility as the production welding.

(d) The welded plate shall be 100% ultrasonic inspected in accordance with 6.

(e) A minimum of two longitudinal bend tests in accordance with 7(a) shall be taken from material from at least two corners of the qualification test plate (4 tests total).

(f) A minimum of two tensile tests in accordance 7(b) shall be taken from material from at least two corners of the qualification test plate (4 tests total).

(g) Remaining material from a successful performance qualification plate using a qualified procedure may be used for production requirements.

4 PRODUCTION WELDING

(a) The welded plate shall be 100% ultrasonic inspected in accordance with 6.

(b) A minimum of two tensile tests taken from material from at least two corners of each production plate shall be required (4 tests total).

(c) A minimum of two bend tests taken from material from at least two corners of each production plate shall be required (4 tests total).

(d) When impact testing is required by the customer, other Code sections, or other standards, a minimum of three Charpy V-notch tests for each weld and each test temperature shall be taken from representative material from each production plate and tested in accordance with 7(c) (3 tests for each weld and test temperature).

5 WELDING VARIABLES

Qualified welding procedures may be applied to production within the limits of the welding variables defined as follows:

(a) The following shall be considered essential variables:

(1) a change in the number of layers or sequence of assembly of multiple layer plates

(2) a change in the type or grade of the prime, interlayer (if used), or backer material

(3) a change in the heat treat condition of the prime, interlayer (if used), or backer material

(4) a change from a backer consisting of one material to a multilayer backer

(5) an increase in the length or the width of the plates to be welded of more than 10%

(6) a change in thickness of the prime or interlayer (if used) of more than 25%

(7) a reduction in the total thickness of the backer of more than 50%

(8) addition or deletion of an interlayer welded simultaneously in the same shot as the prime and backer

(9) a change in the stand-off between the prime and the backer (or interlayer and interlayer to backer, when used) of more than +100% or -50%

(10) QW-406.1

(11) QW-407.1

(12) a change in roughness of the prepared weld surface greater than 50% of the roughness (in microinches RMS) of the qualified surface

(13) a change in the material used for stand-off spacers that will be inside the area of usable material

(14) addition, deletion, or a change of an anvil

(15) a change in the location of the initiation point from the perimeter of the plate to the interior of the plate

(16) an increase in the run of explosive of more than 10%

(17) a change in explosive composition of more than 10%

(18) a change in the explosive loading of more than 10%

(b) The following shall be considered nonessential variables:

(1) QW-410.31

(2) a change in the arrangement or spacing of stand-off spacers of more than 25%

(3) addition, deletion, or a change in buffer

(4) a change in the material used for stand-off spacers that will be outside the area of usable material

(5) a change in booster type or booster protection

(6) addition, deletion, or change in extension bar

(7) addition, deletion, or change in score

6 EXAMINATION

Explosion welded plate material shall be 100% nondestructively tested using contact ultrasonic inspection in accordance with Section V, Article 4. The acceptance standard shall be based on a calibration block with 5 mm diameter flat bottomed holes drilled to each weld interface.

7 MECHANICAL TEST REQUIREMENTS

(a) Tensile properties shall be demonstrated by testing in accordance with Section IX, QW-150.

(1) Standard round tensile specimens as defined in Section IX, Figure QW-462.1(d) taken in the Z-direction from the welded plate shall be used. Tests of plates welded with one or more interlayers may be taken from the finished multilayer welded plate with a single test representing all welds.

(2) Acceptance criteria for tensile tests shall be as defined in QW-153.1 considering interlayer materials as base metals when plates with interlayers are tested.

(b) Weld ductility shall be demonstrated by testing in accordance with Section IX, QW-160 using Longitudinal Bend tests in accordance with QW-161.5, except specimens shall be cut from the thickness of the plate with the weld oriented along the length of the specimen. No distinction between face and root side is required.

(1) Specimen dimensions shall be in accordance with Figure QW-462.3(b) and shall be at least $\frac{3}{8}$ in. thick and $1\frac{1}{2}$ in. wide or wider if necessary to capture all of the welds in a multilayer material, with a minimum of the lesser of $\frac{1}{2}$ in. or the thickness of each face material included in the overall width.

(2) Bend testing shall be in accordance with Section IX, QW-162. Bend testing shall be performed on a jig using same criteria described in Section IX, QW-466.1 for the component material with the largest ram diameter "A" allowable for the materials in the weld, including any interlayer materials.

(3) Acceptance criteria for longitudinal bend tests shall be as defined in Section IX, QW-163.

(c) Weld toughness shall be demonstrated by testing in accordance QW-171. Charpy V-notch specimens shall be made with the notch located at the weld interface or at each weld interface for multilayer joints.

(1) Acceptance criteria for impact tests shall be as defined in Section IX, QW-171.

8 DEFINITIONS

anvil: a heavy plate material, usually steel, used to support backer components of insufficient thickness to withstand the explosive force without excessive deformation.

backer component (backer): material to which the prime (and interlayer, if used) is welded, usually of greater thickness than the prime and usually providing a structural function in the clad plate.

booster: a high explosive used to create sufficient energy to initiate the detonation of the base explosive charge.

booster protection: material placed between the booster and the prime to protect the prime metal surface.

buffer: a substance used to inhibit chemical reaction between the explosive and the prime, usually applied as a paint-like coating.

explosion weld: a weld produced between two materials using the energy released during a controlled detonation of an explosive material. A clean surface is achieved by expulsion of a jet of surface oxides and impurities ahead of the collision point of the two materials. Atomic closeness is achieved by the force of the explosion.

explosion welding (EXW): a welding process that uses explosive energy to generate a jet of surface oxides and impurities that is expelled ahead of the collision point of the two materials to achieve a clean surface and to supply force to achieve atomic closeness.

explosion welding operator: the member of the team that assembles the plate for welding is responsible to check the assembly and to verify the explosive composition, loading, and detonation, and is therefore responsible for the overall weld joint.

explosive composition: the chemical composition, the physical characteristics, and other factors that affect the detonation velocity and energy released by the explosive.

explosive loading: the amount (mass) of explosive used per unit area of material to be welded.

extension bar: a steel bar surrounding the perimeter of the prime used to maintain a steady state of explosive energy beyond the edge of the plate. Can be compared to run-off tabs in conventional welding.

frame: a steel frame surrounding the explosive that is set at an approximate height based on the density of the explosive. Frame height is a secondary calculation. The required explosive loading is maintained.

initiation point: the point on the predetonation assembly of material where the detonation is initiated. Usually this is at the perimeter of the plate, e.g., at a corner or center of the long side, but may be in the interior.

interlayer component (interlayer): a material placed between the prime and the backer to improve metallurgical compatibility in the overall weld. Interlayers may be welded to the backer separately (in which case they are the prime for the specific welding procedure) or in the same explosion welding operation used to weld the prime and backer.

multilayer backer: a backer component that consists of two or more previously explosion welded plates.

parallel plate explosion welding: the arrangement of flat plates in a parallel configuration with a controlled stand-off in preparation for explosion welding.

prime component (prime): the material closest to the explosive that is to be welded to the backer component. The prime usually provides special surface characteristics like corrosion resistance or metallurgical compatibility to the backer or intermediates. The prime is usually (but not always) of lesser thickness than the backer.

run of explosive: the distance from the initiation point to the extreme limit of the plate.

score: a groove cut into the prime along the periphery of the plate that controls the location of edge shearing during explosion welding.

stand-off: the spacing between the prime and the backer materials (or the prime and the interlayer, and interlayer and backer where interlayers are used) that are being joined by the EXW process.

9 DOCUMENTATION

Use of this Case shall be documented on the applicable PQR, WPS, WOPQ, and Data Report Forms.

CAUTION: Dissimilar metal joints are known to be susceptible to galvanic and other corrosion effects. Users shall satisfy themselves, at minimum, by appropriate corrosion tests at conditions comparable to the service conditions to which the weld joint will be exposed, including start-up and upset conditions, that the weld and adjacent material will not suffer adverse metallurgical, corrosion, or mechanical degradation.

Case 2494-2

Corrosion-Resistant Cu-Sb Carbon Steel Tube and Seamless Pipe

Section I

Approval Date: March 28, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May seamless and electric resistance welded Cu-Sb carbon steel tube and seamless pipe with chemical analysis shown in [Table 1](#), the mechanical properties shown in [Table 2](#), and otherwise conforming to the requirements in SA-423/SA-423M for tube and SA-106/SA-106M for pipe be used in Section I construction?

Reply: It is the opinion of the Committee that the material listed in the Inquiry may be used in Section I construction, provided the following requirements are met:

(a) The material shall meet the chemical analysis and minimum tensile requirements given in [Tables 1](#) and [2](#), and shall otherwise meet the requirements of SA-423/SA-423M for tube and SA-106/SA-106M for pipe.

(b) The maximum allowable stress values for the material are given in [Tables 3](#) and [3M](#). The maximum design temperature is 797°F (425°C).

(c) Separate welding procedure and performance qualifications shall be conducted for the material in accordance with Section IX. For the purpose of postweld heat treatment, this material shall be considered P-No. 1 Gr. No. 1.

(d) This Case number shall be referenced in the documentation and marking of the material and recorded on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon, max.	0.06
Manganese	0.70–1.40
Phosphorus, max.	0.020
Sulfur, max.	0.020
Silicon, max.	0.55
Copper	0.25–0.45
Nickel, max.	0.50
Molybdenum, max.	0.20
Antimony	0.05–0.15

Table 2
Tensile Requirements

Tensile strength, min. ksi (MPa)	55 (380)
Yield strength, min. ksi (MPa)	33 (230)
Elongation in 2 in. (50 mm), min. %	35
For tube having a specified wall thickness of less than $\frac{5}{16}$ in. (8 mm), if tested using longitudinal strip test specimen	[Note (1)]

NOTE: (1) The minimum elongation shall be determined by the following equation, with the calculated value rounded to the nearest percent:

$$E = 56t + 16.5$$

where

E = minimum elongation in 2 in. (50 mm), %

t = specified wall thickness, in.

Table 3
Maximum Allowable Stresses

For Metal Temperature Note Exceeding, °F	Allowable Stress Values, ksi	
	Seamless	Welded [Note (1)]
-20 to 100	15.7	13.4
200	15.7	13.4
300	15.7	13.4
400	15.7	13.4
500	15.7	13.4
600	15.2	12.9
650	14.4	12.2
700	13.8	11.7
750	13.5	11.5
800	13.5 [Note (2)]	11.5 [Note (2)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) These *S* values include a 0.85 weld efficiency factor. Values for seamless tubing may be used provided the following additional restrictions requirements are met:
 - (a) The tubing shall be used for boiler, waterwall, superheater, and economizer tubes that are enclosed within the setting.
 - (b) The maximum outside diameter shall be 3½ in. (89 mm).
 - (c) The weld seam of each tube shall be subjected to an angle beam ultrasonic inspection per SA-450.
 - (d) A complete volumetric inspection of the entire length of each tube shall be performed in accordance with SA-450.
 - (e) Material test reports shall be supplied.
- (2) This value is provided for interpolation purposes only.

Table 3M
Maximum Allowable Stresses

For Metal Temperature Note Exceeding, °C	Allowable Stress Values, MPa	
	Seamless	Welded [Note (1)]
-30 to 40	109	92.7
65	109	92.7
125	109	92.7
150	109	92.7
175	109	92.7
200	109	92.7
225	109	92.7
250	109	92.7
275	109	92.7
300	109	92.7
325	103	87.6
350	97.9	83.2
375	94.8	80.6
400	93.3	79.3
425	92.9	79.0

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) These *S* values include a 0.85 weld efficiency factor. Values for seamless tubing may be used provided the following additional restrictions requirements are met:

- (a) The tubing shall be used for boiler, waterwall, superheater, and economizer tubes that are enclosed within the setting.
- (b) The maximum outside diameter shall be 3½ in. (89 mm).
- (c) The weld seam of each tube shall be subjected to an angle beam ultrasonic inspection per SA-450.
- (d) A complete volumetric inspection of the entire length of each tube shall be performed in accordance with SA-450.
- (e) Material test reports shall be supplied.

Case 2496-4

27Cr-7.6Ni-1Mo-2.3W-N UNS S32808, Solution Annealed Austenitic-Ferritic Duplex Stainless Steel Plate, Seamless Tubing, Seamless Pipe, Forgings, and Bar for Class 2

Section VIII, Division 1; Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed 27Cr-7.6Ni-1Mo-2.3W-N, UNS S32808, seamless tubing, seamless pipe, plate, forgings, and bar conforming to the specifications listed in [Table 1](#) be used in welded construction under the rules of Section VIII, Division 1 and Division 2, Class 2?

Reply: It is the opinion of the Committee that solution-annealed 27Cr-7.6Ni-1Mo-2.3W-N, UNS S32808 material, as described in the Inquiry, may be used in welded construction under the rules of Section VIII, Division 1 and Division 2, Class 2, provided that the following additional requirements are met:

(a) For Section VIII, Division 1 application, the rules of Subsection C, Part UHA for austenitic-ferritic duplex stainless steels shall apply. For Section VIII, Division 2, application, the rules for austenitic-ferritic duplex stainless steels shall apply.

(b) The yield strength and tensile strength values shall be as given in [Tables 2](#) and [2M](#).

(c) The maximum allowable stress values for the material shall be as given in [Tables 3](#) and [3M](#). The maximum design temperature is 662°F (350°C).

(d) For external pressure design, Fig. HA-5 in Section II, Part D shall be used.

(e) Physical properties for UNS S32808 shall be as follows:

(1) modulus of elasticity, as given in Table TM-1 of Section II, Part D, Subpart 2, for Material Group B

(2) coefficients of mean linear thermal expansion, as given in [Table 4](#)

(3) thermal conductivity and diffusivity, as given in Table TCD of Section II, Part D, Subpart 2 for Material Group J

(4) density, 0.284 lb/in.³ (7860 kg/m³)

(f) Separate welding procedure and performance qualifications shall be performed in accordance with Section IX.

(g) Heat treatment after welding or fabrication is neither required nor prohibited. When heat treatment is performed, the tube, pipe, or plate material shall be heat treated at a temperature of 1,925°F to 2,100°F (1 050°C to 1 150°C) followed by rapid cooling in air or water.

(h) Product analysis tolerances for SA-789/SA-789M tubing, ASTM A790/A790M pipe, and SA-240/SA-240M plate shall be as specified in Table 1 of SA-484/SA-484M.

(i) This Case number shall be included in the documentation and marking of SA-789/SA-789M tubing, ASTM A790/A790M pipe, and SA-240/SA-240M plate, and in the Manufacturer's Data Report for all product forms.

Table 1
Specifications

Specification	Product Form
SA-789/SA-789M [Note (1)]	Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
SA-240/SA-240M	Chromium and Chromium-Nickel Stainless Steel Plate for Pressure Vessels and General Service
ASTM A182/ A182M-14a	Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A479/ A479M-13	Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels
ASTM A790/ A790M-14	Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe

NOTE: (1) Only the editions listed in Section II, Part A, Mandatory Appendix II, Table II-200-1 (2013 edition) under SA-789/SA-789M without the application of item (f) may be used for this Case.

Table 2
Yield Strength, S_y , and Tensile Strength, S_u , Values

For Metal Temperature Not Exceeding, °F	Yield Strength Values, ksi [Note (1)]		Tensile Strength Values, ksi [Note (2)]	
	SA-789/SA-789M and ASTM A790/A790M for $t < 0.40$ in.	SA-789/SA-789M and ASTM A790/A790M for $t \geq 0.40$ in.; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M	SA-789/SA-789M and ASTM A790/A790M for $t < 0.40$ in.	SA-789/SA-789M and ASTM A790/A790M for $t \geq 0.40$ in.; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M
100	80.0	72.0	116.0	102.0
200	65.5	61.2	113.7	101.5
300	60.7	55.9	109.1	95.8
400	57.6	53.5	106.5	93.6
500	56.0	52.9	106.0	93.6
600	56.0	52.5	106.0	93.6
650	56.0	51.9	106.0	93.6
700 [Note (3)]	56.0	51.1	106.0	93.2

NOTES:

(1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).

(2) See Section II, Part D, Subpart 1, Table U, General Note (b)

(3) These values are provided for interpolation purposes only. The maximum design temperature of this material is 662°F.

Table 2M
Yield Strength, S_y , and Tensile Strength, S_u , Values

For Metal Temperature Not Exceeding, °C	Yield Strength Values, MPa [Note (1)]		Tensile Strength Values, MPa [Note (2)]	
	SA-789/SA-789M and ASTM A790/A790M for $t < 10$ mm	SA-789/SA-789M and ASTM A790/A790M for $t \geq 10$ mm; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M	SA-789/SA-789M and ASTM A790/A790M for $t < 10$ mm	SA-789/SA-789M and ASTM A790/A790M for $t \geq 10$ mm; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M
40	550	500	800	700
65	478	452	800	700
100	445	420	779	691
125	429	401	764	671
150	417	388	752	657
175	406	378	743	648
200	397	372	735	643
225	390	369	731	642
250	386	368	731	642
275	384	367	731	642
300	384	366	731	642
325	384	363	731	642
350	384	359	731	642

NOTES:

(1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).

(2) See Section II, Part D, Subpart 1, Table U, General Note (b).

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F [Note (1)]	Division 1 Values, ksi		Division 2 Values, ksi	
	SA-789 Tube; Pipe, $t < 0.40$ in.	SA-789/SA-789M and ASTM A790/A790M for $t \geq 0.40$ in.; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M	SA-789/SA-789M and ASTM A790/A790M for $t < 0.40$ in.	SA-789/SA-789M and ASTM A790/A790M for $t \geq 0.40$ in.; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M
100	33.1	29.1	48.3	42.5
200	32.5	29.0	43.7	40.8
300	31.2	27.4	40.4	38.2
400	30.4	26.8	38.4	35.7
500	30.3	26.8	37.3	35.2
600	30.3	26.8	37.2	35.0
650	30.3	26.8	37.2	34.6
700 [Note (2)]	30.3	26.6	37.2	34.1

NOTES:

- (1) This material may embrittle by exposure to moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.
- (2) These values are provided for interpolation purposes only. The maximum design temperature of this material is 662°F.

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C [Note (1)]	Division 1 Values, MPa		Division 2 Values, MPa	
	SA-789M Tube; Pipe, SA-789/SA-789M and ASTM A790/A790M for $t < 10$ mm	SA-789/SA-789M and ASTM A790/A790M for $t \geq 10$ mm; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M	SA-789/SA-789M and ASTM A790/A790M for $t < 10$ mm	SA-789/SA-789M and ASTM A790/A790M for $t \geq 10$ mm; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M
40	229	200	333	292
65	229	200	318	292
100	223	197	297	280
125	218	192	286	268
150	215	188	278	258
175	212	185	271	252
200	210	184	265	248
225	209	183	260	246
250	209	183	257	245
275	209	183	256	244
300	209	183	256	244
325	209	183	256	242
350	209	183	256	240

NOTE: (1) This material may embrittle by exposure to moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

Table 4
Mean Coefficients of Thermal Expansion

Temperature Range, °C	Coefficient, (/°C) × 10 ⁶	Temperature Range, °F	Coefficient, (/°F) × 10 ⁶
RT-100	13.7	RT-212	7.6
RT-150	13.9	RT-302	7.7
RT-200	14.0	RT-392	7.8
RT-250	14.2	RT-482	7.9
RT-300	14.4	RT-572	7.9
RT-350	14.5	RT-662	8.0
RT-400	14.7	RT-752	8.1

Case 2498

Use of SA/EN 10028-2, Grades P235GH and P265GH Steel

Section VIII, Division 1

Approval Date: June 20, 2008

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use steel plate, manufactured in accordance with SA/EN 10028-2, Grades P235GH and P265GH to a maximum thickness of 2 $\frac{1}{4}$ in. (60 mm) in the construction of pressure vessels under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that steel plate manufactured in accordance with SA/EN 10028-2, Grades P235GH and P265GH to a maximum thickness of 2 $\frac{1}{4}$ in. (60 mm) may be used, in Section VIII, Division 1 construc-

tion, provided the following additional requirements are met:

(a) The design temperature shall not exceed 700°F (371°C).

(b) The maximum allowable stress values for the materials shall be those given in Tables 1 and 1M.

(c) The material shall be considered as P No. 1, Group No. 1.

(d) For external pressure design, use Fig. CS-2 of Section II, Part D.

(e) In UCS-66 the material shall be assigned to Curve B in the as-rolled condition and Curve D in the normalized condition.

(f) This Case number shall be on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Grade P235GH Maximum Allowable Stress Values, ksi	Grade P265GH Maximum Allowable Stress Values, ksi
100	14.9	17.0
150	14.9	17.0
200	14.9	17.0
250	14.9	17.0
300	14.9	17.0
400	14.9	17.0
500	14.9	17.0
600	14.9	17.0
650	14.9	17.0
700	12.5	15.6

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Grade P235GH Maximum Allowable Stress Values, MPa	Grade P265GH Maximum Allowable Stress Values, MPa
40	103	117
65	103	117
100	103	117
125	103	117
150	103	117
200	103	117
250	103	117
300	103	117
325	103	117
350	96.8	117
375 [Note (1)]	85.0	108

NOTE: (1) These values are provided for interpolation purposes only. The maximum use temperature is 371°C.

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Case 2500

Use of ASTM A576 Hot-Wrought Carbon Steel Bars for Forming Fittings for HLW Construction

Section IV

Approval Date: November 2, 2004

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May internally threaded fittings formed from ASTM A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, by the cold heading process be used in the construction of water heaters and storage tanks to the rules of Part HLW?

Reply: It is the opinion of the Committee that the material specified in the Inquiry may be used in the forming of fittings for water heaters and storage tanks under the rules of Section IV, Part HLW, with the following additional requirements:

- (a) The grades shall be limited to 1008 through 1015.
- (b) Supplementary requirement, S1, Cold-Working Quality, of ASTM A576 shall apply.

(c) A certificate shall be provided that identifies the material, with its material specification, grade, and Rockwell B hardness number. This number shall be between 55 and 78.

(d) The fitting size shall not exceed NPS 1 (DN 25).

(e) The fitting manufacturer shall provide the purchaser with a Certificate of Compliance that states compliance with this Case and identifies by part number all of the purchaser's fittings that comply with requirements of this Case.

(f) Identification of the fittings shall conform to the requirements of HLW-203(b).

(g) Welding procedure and performance qualification shall be performed in accordance with Section IX and the additional requirements of Part HLW.

(h) The maximum allowable working pressure for a vessel incorporating these fittings shall be established by a proof test per HLW-500.

(i) All other requirements of Part HLW shall be met.

(j) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2511

Requirements for Use of an Alternative Test Method Under PG-73.4.2.2

Section I

Approval Date: August 3, 2005

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the requirements of PG-73.4.2.2(b), requiring owner and boiler manufacturer acceptance to use an alternative test method, be waived?

Reply: It is the opinion of the Committee that the requirements of PG-73.4.2.2(b), requiring owner and boiler manufacturer acceptance to use an alternative test method, may be waived, provided that the safety valve manufacturer and either the boiler manufacturer or boiler owner agree to invoke this Code Case.

This Case number is to be included with the safety valve stamping information required by PG-110.

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Case 2512

18Cr-10Ni-3Cu-Ti-Cb Seamless Austenitic Stainless Steel Tube

Section I

Approval Date: October 27, 2005

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-treated 18Cr-10Ni-3Cu-Ti-Cb seamless austenitic stainless steel tube with chemical analysis shown in [Table 1](#), the mechanical properties shown in [Table 2](#), and otherwise conforms to applicable requirements in SA-213 be used for steam service in Section I construction?

Reply: It is the opinion of the Committee that the material listed in the Inquiry may be used for steam service in Section I construction, provided that the following requirements are met:

(a) The material shall meet the chemical analysis and minimum tensile requirements described in the Inquiry, and shall otherwise meet the requirements of SA-213 as applicable, except as shown in paras. (b) and (c).

(b) The minimum solution-treating temperature for this material shall be 2120°F (1160°C).

(c) This material shall have a hardness not exceeding 192 HB/200 HV (90 HRB).

(d) The rules of PG-19 for TP321H shall apply for this material, except that solution treatment, when required, shall be at the minimum temperature of 2120°F (1160°C) and the recommended maximum temperature of 2270°F (1245°C).

(e) The maximum allowable stress values for the material shall be as given in [Tables 3](#) and [3M](#). The maximum design temperature is 1382°F (750°C).

(f) Separate welding procedure and performance qualification shall be conducted for the material in accordance with Section IX.

(g) This Case number shall be referenced in the documentation and marking of the material and recorded on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.07–0.14
Manganese, max.	2.00
Phosphorus, max.	0.040
Sulfur, max.	0.010
Silicon, max.	1.00
Nickel	9.00–12.00
Chromium	17.50–19.50
Titanium	0.10–0.25
Columbium plus Tantalum	0.10–0.40
(Ti+Cb/2)/C	2.0–4.0
Copper	2.50–3.50
Boron	0.0010–0.0040

Table 2
Mechanical Property Requirements

Tensile strength, min. ksi (MPa)	73 (500)
Yield strength, min. ksi (MPa)	30 (205)
Elongation in 2 in. or 50 mm, min., %	35

Table 3
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi	Allowable Stress Values, ksi
-40 to 100	20.0	20.0
200	17.6	20.0 [Note (1)]
300	17.0	20.0 [Note (1)]
400	16.8	20.0 [Note (1)]
500	16.7	20.0 [Note (1)]
600	16.5	20.0 [Note (1)]
650	16.2	20.0 [Note (1)]
700	15.9	20.0 [Note (1)]
750	15.6	20.0 [Note (1)]
800	15.2	20.0 [Note (1)]
850	14.8	19.8 [Note (1)]
900	14.3	19.4 [Note (1)]
950	13.9	18.8 [Note (1)]
1000	13.5	18.3 [Note (1)]
1050	13.2	17.8 [Note (1)]
1100	12.9	17.4 [Note (1)]
1150	12.6	15.3 [Note (1)]
1200	11.8	11.8
1250	9.0	9.0
1300	7.1	7.1
1350	5.7	5.7
1400	4.8 [Note (2)]	4.8 [Note (2)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these high stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only.

Table 3M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa	Allowable Stress Values, MPa
-30 to 40	138	138
65	126	138 [Note (1)]
100	121	138 [Note (1)]
125	118	138 [Note (1)]
150	117	138 [Note (1)]
175	116	138 [Note (1)]
200	116	138 [Note (1)]
225	116	138 [Note (1)]
250	116	138 [Note (1)]
275	115	138 [Note (1)]
300	114	138 [Note (1)]
325	113	138 [Note (1)]
350	111	138 [Note (1)]
375	109	138 [Note (1)]
400	107	138 [Note (1)]
425	105	138 [Note (1)]
450	102	137 [Note (1)]
475	99.7	135 [Note (1)]
500	97.1	131 [Note (1)]
525	94.5	128 [Note (1)]
550	92.2	124 [Note (1)]
575	90.0	122 [Note (1)]
600	88.2	119 [Note (1)]
625	86.6	102 [Note (1)]
650	80.7	80.7
675	63.3	63.3
700	50.5	50.5
725	41.5	41.5
750	35.2	35.2

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) Due to the relatively low yield strength of this material, these high stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Case 2514-1

Use of SA-182 F22V, SA-336 F22V, SA-541 22V, SA-542 Type D, Class 4a, and SA-832 22V to 850°F (454°C)

Section VIII, Division 3

Approval Date: July 7, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SA-182 F22V, SA-336 F22V, SA-541 22V, SA-542 Type D, Class 4a, and SA-832 22V be used at a temperature of less than or equal to 850°F (454°C) for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that SA-182 F22V, SA-336 F22V, SA-541 22V, SA-542 Type D, Class 4a, and SA-832 22V may be used for Section VIII, Division 3 construction at a temperature of less than or equal to 850°F (454°C), provided the following conditions are met:

(a) The maximum continuous time and temperature shall be included in user's design specification.

(b) Design temperature is equal to or less than 850°F (454°C).

(c) The yield strength value, S_y , shall be those shown in Tables 1 or 1M.

(d) The diameter ratio ($Y = D_o/D_i$) shall be equal to or less than 1.2.

(e) The design pressure for a cylindrical shell shall not exceed the limit set by eq. (1).

$$P_D = \left(\frac{2}{3}\right) \times k_c \times S_y \times l_n(Y) \quad (1)$$

where

D_i = inside diameter

D_o = outside diameter

k_c = membrane adjustment factor from Table 2. Interpolation may be used for intermediate values of design temperature.

P_D = design pressure

S_y = yield strength value at design temperature

Y = diameter ratio D_o/D_i

(f) The design pressure for a spherical shell shall not exceed the limit set by eq. (2).

$$P_D = \left(\frac{4}{3}\right) \times k_c \times S_y \times l_n(Y) \quad (2)$$

(g) For all components except standard pressure parts and bolted flanges specified in (m), the elastic analysis shall be performed. The local primary membrane, P_l , local primary membrane plus bending ($P_l + P_b$), and primary plus secondary stresses intensity ($P_l + P_b + Q$) shall not exceed the following limits:

$$P_m \leq k_c \times S_y / 1.5 \quad (3)$$

$$P_l \leq k_b \times S_y \quad (4)$$

$$P_l + P_b \leq \alpha \times k_b \times S_y / 1.5 \quad (5)$$

$$P_l + P_b + Q \leq 2 \times k_b \times S_y \quad (6)$$

α = shape factor [see KD-210(o)]

k_b = local, bending and secondary adjust factor from Table 4. Interpolation may be used for intermediate values of the design temperature.

(h) The inelastic analysis for the shakedown and total accumulated inelastic strain including the effect of creep shall be performed for pressure parts except standard pressure parts and bolted flanges specified in (m). The elastic perfectly plastic stress strain curve using S_y and creep rate specified in the following equation shall be used for the analysis.

The following creep rate shall be used in the creep analysis:

(U.S. Customary Units)

$$\log \sigma_{ksi} = -0.0263 \times (P/1000)^2 + 0.8159 \times (P/1000) - 4.6063$$

(SI Units)

$$\log \sigma_{\text{MPa}} = -0.0263 \times (P/1000)^2 + 0.8159 \times (P/1000) - 3.7677$$

where

σ = stress, ksi (MPa)

P = Larson-Miller parameter

$$= (T_C + 273.16) \times (20 - \log \epsilon_{\min})$$

$$= (T_F/1.8 + 255.38) \times (20 - \log \epsilon_{\min})$$

T_C = temperature, °C

T_F = temperature, °F

ϵ_{\min} = upper bound minimum creep rate, %/hr

The total accumulated inelastic strain shall not exceed the following:

	For weld and heat affected zone	Other Parts
Membrane	0.5%	1.0%
Bending	1.25%	2.5%
Local	2.5%	5.0%

A shakedown analysis shall be conducted by using maximum expected operating loads and maximum continuous time at operating temperature for at least 2 cycles. The analysis shall demonstrate that the unloading and subsequent reloading portions of the cycle are elastic at any point. The hold time at the maximum load that is used in the analysis shall be at least one year to consider the effects of creep on shakedown.

(i) ($k_c \times S_y$) instead of S_y shall be used in the pure shear stress evaluation in KD-232 and bearing stress evaluation in KD-233.

(j) When the design cycles are calculated in accordance with KD-3, the design fatigue curve for 2¼Cr-1Mo-¼V steel shown in Figures 1 and 1M and Table 3 shall be used. Interpolation may be used for the intermediate temperature between 800°F (427°C) and 850°F (454°C). A mean stress correction is not necessary. The design cycles shall be less than or equal to 1,000 cycles.

(k) When the design cycles are calculated in accordance with KD-4, the fatigue crack growth rate factors for high strength low alloy steels shown in Tables KD-430 or KD-430M shall be used. The creep crack growth during hold time shall be considered.

(l) The design using autofrettage per KD-5, layered vessel constructions per KD-8 and wire-wound vessel construction per KD-9 shall not be used.

(m) Standard pressure parts that comply with an ASME product standard listed in Table KG-141 and flange joints in accordance with Appendix 2 of Section VIII, Division 1 may be used as closure components at the pressure temperature rating listed in the ASME standard or calculated per Appendix 2 of Section VIII, Division 1. These

parts shall be made of materials listed in Section VIII, Division 3. When calculations are performed for supplementary loads, the following stress limits are applied. The average primary stress intensity in bolts shall be based on the thread root diameter and shall not exceed the maximum allowable stress values of S in Table 3 of Section II, Part D. Primary plus secondary membrane stress intensity in bolts shall not exceed $2S$. Primary plus secondary membrane plus bending stress intensity in bolts shall not exceed $3S$ due to the combination of both the design loads and preloads. Stress intensification due to the threads shall not be considered in the above analysis. The primary plus bending stress for the bolted flange shall not exceed $1.5S$ and primary plus secondary stress for the bolted flange shall not exceed $3S$.

(n) Two sets of tension specimens and one set of Charpy V-notch impact specimens shall be tested. One set each of tension specimens shall be exposed to heat treatment Condition A. The second set of tension specimens and the set of Charpy impact specimens shall be exposed to heat treatment Condition B.

(1) Condition A: maximum anticipated cycles of heat treatment during fabrication and field repair (if required) of vessel portion

(2) Condition B: minimum anticipated cycle(s) of heat treatment during fabrication of vessel portion

(o) Welding procedure qualifications using a production weld consumable shall be made for material welded to itself or to other materials. The qualifications shall conform to requirements of Section IX, and the maximum tensile strength at room temperature shall be 110 ksi (758 MPa) for heat treatment Conditions A and B.

(p) Deposited weld metal from each heat or lot of electrodes, filler rod and filler wire-flux combination shall be tested for each welding process to be used. The maximum tensile strength specified in (o) and the minimum tensile strength for the base metal shall be met in PWHT Conditions A and B. The minimum CVN impact properties specified in (s) shall be met in PWHT Condition B. Testing shall be in general conformance with SFA-5.5 for covered electrodes, SFA-5.23 for filler wire-flux combinations, and SFA-5.28 for gas shielded welding.

(q) The requirements for postweld heat treatment for this material (P-No. 5C) shall be as specified for P-No. 5A material in Table KF-402.1 in Section VIII, Division 3.

(r) The welding process shall be SAW, SMAW, GTAW, or GMAW. The deposited weld metal shall meet the compositional requirements listed in Table 4.

(s) Average transverse Charpy V-notch impact values for base metal, weld metal, and heat affected zone at the lower temperature of -20°F (-29°C) or the minimum design metal temperature shall not be less than 40 ft-lb (54 J) with no single value below 35 ft-lb (48 J) after exposure to the vessel minimum postweld heat treatment cycle. The minimum postweld heat treatment

temperature and hold time shall be as specified in Table KF-402.1.

In addition each heat of base metal, welding materials, and production weld tests for deposited weld metal and heat affected zone shall be tested for temper embrittlement susceptibility to determine the respective transition temperature shifts following step cooling heat treatment and shall meet the transition temperature shift relationship provided in (t). When the purchaser agrees, in lieu of step cooling tests, chemical composition limits for the J-factor and X-bar factor specified in API 934, December 2000 Edition, may be used, with the additional requirement that the X-bar chemical composition limits for welding consumables shall also be applied to the base metals and shall be less than or equal to 15. The step cooling heat treatment cycle shall be as follows:

- (1) heat to 600°F (316°C), heating rate not critical
- (2) heat at 100°F (56°C)/hr maximum to 1100°F (593°C)
- (3) hold at 1100°F (593°C) for 1 hr
- (4) cool at 10°F (6°C)/hr maximum to 1000°F (538°C)
- (5) hold at 1000°F (538°C) for 15 hr
- (6) cool at 10°F (6°C)/hr maximum to 975°F (524°C)
- (7) hold at 975°F (524°C) for 24 hr
- (8) cool at 10°F (6°C)/hr maximum to 925°F (496°C)
- (9) hold at 925°F (496°C) for 60 hr
- (10) cool at 5°F (3°C)/hr maximum to 875°F (468°C)
- (11) hold at 875°F (468°C) for 100 hr
- (12) cool at 50°F (28°C)/hr maximum to 600°F (316°C)
- (13) cool to ambient temperature in still air

(t) The transition temperature shift relationship is as follows:

$$vTr_{40} + 2.5\Delta vTr_{40} \leq 50^{\circ}\text{F} (10^{\circ}\text{C})$$

where

vTr_{40} = 40 ft-lb (54 J) minimum transition temperature before step cooling at minimum PWHT

ΔvTr_{40} = shift in the 40 ft-lb (54 J) minimum transition temperature due to step cooling at minimum PWHT ($vTr_{40\ sc} - vTr_{40}$)

$vTr_{40\ sc}$ = 40 ft-lb (54 J) minimum transition temperature after step cooling at minimum PWHT

(u) Caution is advised when using this material above 700°F (375°C). After exposure to temperature above 700°F (375°C), this material may exhibit temper embrittlement and stress relaxation effects. The designer shall consider these effects and their influence on the vessel.

(v) All other requirements of Section VIII, Division 3 shall be satisfied.

(w) This Case number shall be marked on the material, shown and documented on the material test report, and shown on the Manufacturer's Data Report.

**Table 1
Values of Yield Strength**

Spec. No. Grade, Class	Yield Strength, ksi, for Metal Temperature Not Exceeding, °F										
	100	200	300	400	500	600	650	700	750	800	850
SA-182 F22V, SA-336 F22V, SA-541 22V, SA-542 Type D, Class 4a, SA-832 22V	60	59.5	58.6	57.4	56.0	54.2	53.3	52.3	51.2	50.1	49.0

**Table 1M
Values of Yield Strength**

Spec. No. Grade, Class	Yield Strength, MPa, for Metal Temperature Not Exceeding, °C											
	40	100	150	200	250	300	350	375	400	425	450	475
SA-182 F22V, SA-336 F22V, SA-541 22V, SA-542 Type D, Class 4a, SA-832 22V	414	410	404	396	388	377	366	360	353	346	339	332

GENERAL NOTE: The maximum design temperature for these materials is 454°C. Values above 454°C are provided only for the purpose of interpolation.

**Table 2
Values of K_c And K_b**

Design Temperature	k_c	k_b
Less than or equal to 750°F (399°C)	1.0	0.76
800°F (427°C)	0.98	0.75
825°F (441°C)	0.90	0.75
850°F (454°C)	0.87	0.75

Figure 1
Design Fatigue Curve for 2¹/₄Cr-1Mo-V Steel for Temperatures Not Exceeding 800°F (427°C) and 850°F (454°C)

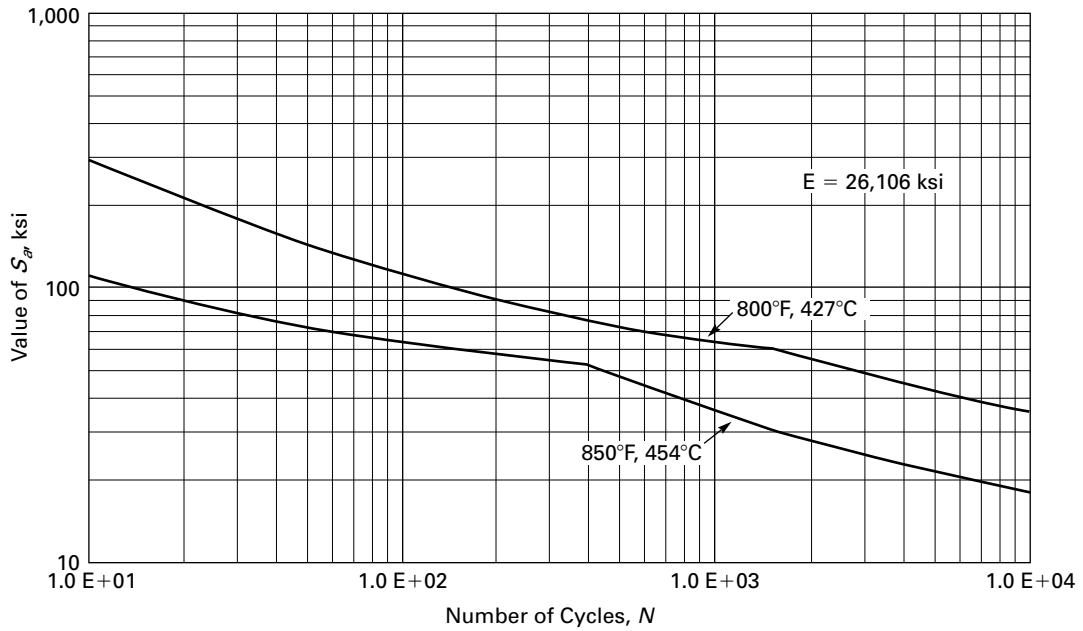


Figure 1M
Design Fatigue Curve for 2¹/₄Cr-1Mo-V Steel for Temperatures Not Exceeding 800°F (427°C) and 850°F (454°C)

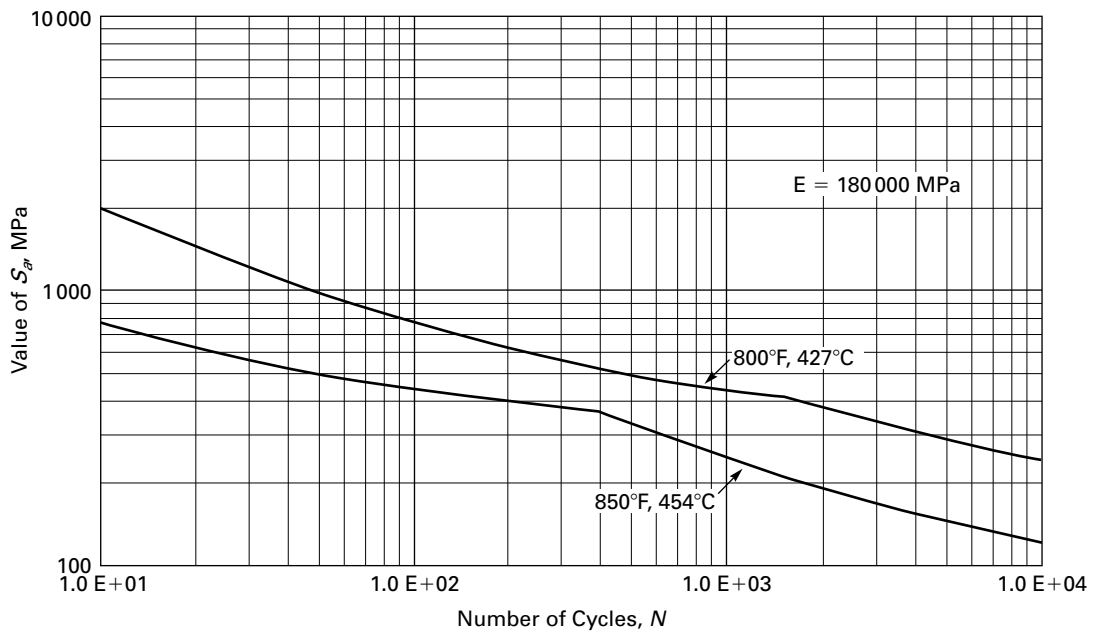


Table 3
Tabulated Values of S_{at} From Figure 1

N	ksi	MPa
For Temperature Not Exceeding 800°F (427°C)		
1.E+00	294	2026
2.E+01	210	1450
5.E+01	142	978
1.E+02	110.0	759
2.E+02	88.9	613
5.E+02	71.2	491
1.E+03	62.8	433
1.72E+03	58.0	400
2.E+03	55.0	379
5.E+03	41.9	289
1.E+04	35.7	246
For Temperature Not Exceeding 850°F (454°C)		
1.E+00	110	759
2.E+01	89	613
5.E+01	71	491
1.E+02	62.8	433
2.E+02	56.8	392
3.97E+02	53.4	368
5.E+02	47.4	327
1.E+03	35.4	244
2E+03	27.5	190
5.E+03	20.9	144
1.E+04	17.8	123

Table 4
Composition Requirements for 2¼Cr-1Mo-¼V Weld Metal

Welding Process	C	Mn	Si	Cr	Mo	P	S	V	Cb
SAW	0.05–0.15	0.50–1.30	0.05–0.35	2.00–2.60	0.90–1.20	0.015 max.	0.015 max.	0.20–0.40	0.010–0.040
SMAW	0.05–0.15	0.50–1.30	0.20–0.50	2.00–2.60	0.90–1.20	0.015 max.	0.015 max.	0.20–0.40	0.010–0.040
GTAW	0.05–0.15	0.30–1.10	0.05–0.35	2.00–2.60	0.90–1.20	0.015 max.	0.015 max.	0.20–0.40	0.010–0.040
GMAW	0.05–0.15	0.30–1.10	0.20–0.50	2.00–2.60	0.90–1.20	0.015 max.	0.015 max.	0.20–0.40	0.010–0.040

Case 2516

Use of Chromium-Silicon Alloy Steel Wire ASTM A401/A401M UNS G92540

(25)

Section VIII, Division 3

Approval Date: August 3, 2005

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ASTM A401/A401M UNS G92540 be used for manufacture of special closure parts designed in accordance with KD-6 of Section VIII, Division 3?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the construction of closure parts conforming to the rules of KD-6 of Section VIII, Division 3, providing the following additional requirements are met:

(a) The maximum design temperature shall be 100°F (40°C).

(b) Tensile strength values to be used in design shall be as shown in [Tables 1](#) and [1M](#). Tensile strength values for intermediate diameters may be linearly interpolated. The tensile strength used for design shall be determined using the diameter found in (c) for material that is not of a round cross-section.

(c) The mechanical testing of the material shall be performed once it is in the final cross-sectional shape and heat treated in accordance with the specification prior to coiling into a helical spring. The material shall be certified to the mechanical properties for a diameter of wire that has a diameter equivalent to the smallest cross-sectional dimension of the wire in the final shape.

(d) Welding is prohibited.

(e) The materials shall not be used for fabrication of other pressure retaining components, such as bolting, wire wound vessels, or wire wound frames.

(f) This Case number shall be shown on the material certification, marking on the material, and on the Manufacturer's Data Report.

Table 1
Tensile Strength Values, S_u

Diameter, in.	S_u , min., ksi
0.032	300
0.041	298
0.054	292
0.062	290
0.080	285
0.092	280
0.120	275
0.135	270
0.162	265
0.177	260
0.192	260
0.219	255
0.250	250

Table 1M
Tensile Strength Values, S_u

Diameter, mm	S_u , min., MPa
0.8	2080
0.9	2070
1.0	2060
1.1	2040
1.2	2020
1.4	2000
1.6	1980
1.8	1960
2.0	1940
2.2	1920
2.5	1900
2.8	1880
3.0	1860
3.5	1840
4.0	1820
4.5	1800
5.0	1780
5.5	1760
6.0	1740

Case 2518-2

SB-407 UNS N06811, 42Ni-29Cr-28Fe-Mo-N, Seamless Pipes and Tubes

Section I; Section VIII, Division 1

Approval Date: December 8, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SB-407 UNS N06811, 42Ni-29Cr-28Fe-Mo-N, seamless pipes and tubes be used in welded construction under the rules of Section I and Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in welded construction under the rules of Section I and Section VIII, Division 1, provided the following requirements are met:

- (a) The y value for use in PG-27 shall be 0.4.
- (b) For Section VIII, Division 1, the rules in Subsection C that shall apply are those in Part UNF for nickel, cobalt, and high nickel alloys.
- (c) The yield and tensile strength values shall be as given in [Table 1](#) and [Table 1M](#).
- (d) The maximum allowable stress values shall be as given in [Tables 2](#) and [2M](#).
- (e) The maximum design temperature is 1,000°F (538°C) when the high set of allowable stresses is used and 1,050°F (565°C) when the low set of allowable stresses is used.

(f) For external pressure values, see Figure NFN-13 of Section II, Part D.

(g) Separate welding procedure and performance qualifications shall be performed in accordance with Section IX.

(h) Postweld heat treatment is neither required nor prohibited. When heat treatment is performed, it shall be performed at 1,920°F (1 050°C) minimum.

(i) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress-corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry, deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials and can result in severe underdeposit wastage and crackage. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Yield and Customary Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
100	35.0	85.0
200	29.7	85.0
300	26.9	79.8
400	24.7	75.6
500	23.0	72.8
600	21.6	71.1
650	21.0	70.5
700	20.5	70.1
750	20.1	69.7
800	19.8	69.2
850	19.6	68.6
900	19.5	67.8
950	19.4	66.7
1,000	19.4	65.2
1,050	19.4	63.3
1,100	19.4	61.0

NOTES:

- (1) General Note (b) of Table Y-1 in Section II, Part D applies to these values.
- (2) General Note (b) of Table U in Section II, Part D applies to these values.

Table 1M
Yield and Customary Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
40	241	586
65	217	586
100	202	586
125	193	586
150	185	569
175	178	553
200	172	539
225	166	527
250	161	517
275	156	510
300	151	504
325	148	500
350	144	497
375	141	494
400	139	491
425	137	488
450	135	484
475	134	478
500	134	471
525	134	463
550	134	452
575	134	441

NOTES:

- (1) General Note (b) of Table Y-1 in Section II, Part D applies to these values.
- (2) General Note (b) of Table U in Section II, Part D applies to these values.

Table 2
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi	Allowable Stress Values, ksi
-20 to 100	23.3	23.3
200	19.8	23.3 [Note (1)]
300	17.9	23.3 [Note (1)]
400	16.5	21.6 [Note (1)]
500	15.3	20.7 [Note (1)]
600	14.4	19.4 [Note (1)]
650	14.0	18.9 [Note (1)]
700	13.7	18.5 [Note (1)]
750	13.4	18.1 [Note (1)]
800	13.2	17.8 [Note (1)]
850	13.1	17.6 [Note (1)]
900	13.0	17.5 [Note (1)]
950	12.9	17.5 [Note (1)]
1000	12.9	17.5 [Note (1)]
1050	12.9	...

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 2M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa	Allowable Stress Values, MPa
-30 to 40	161	161
65	148	161 [Note (1)]
100	135	161 [Note (1)]
125	129	161 [Note (1)]
150	123	161 [Note (1)]
175	119	158 [Note (1)]
200	114	154 [Note (1)]
225	111	149 [Note (1)]
250	107	144 [Note (1)]
275	104	140 [Note (1)]
300	101	136 [Note (1)]
325	98	133 [Note (1)]
350	96	130 [Note (1)]
375	94	127 [Note (1)]
400	93	125 [Note (1)]
425	91	123 [Note (1)]
450	90	122 [Note (1)]
475	90	121 [Note (1)]
500	89	120 [Note (1)]
525	89	120 [Note (1)]
550	89	120 [Note (1)]
575	89 [Note (2)]	...

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) This value is provided for interpolation purposes only. The maximum design temperature is as stated in (d).

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Case 2520

ASTM B444-04 UNS N06852, 50Ni-21.5Cr-17.5Fe-9Mo-Nb, Solution Annealed Seamless Pipes and Tubes

Section I

Approval Date: August 4, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ASTM B444-04 UNS N06852, 50Ni-21.5Cr-17.5Fe-9Mo-Nb, solution annealed seamless pipes and tubes be used in welded construction under the rules of Section I?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in welded construction under the rules of Section I, provided the following additional requirements are met:

(a) The rules of PG-19 for UNS N06690 shall apply for this material.

(b) The y value shall be that for UNS N06690 in Note 6 of PG-27.4.

(c) The maximum allowable stress values shall be as given in [Tables 1](#) and [1M](#). The maximum design temperature is 1,050°F (565°C) when the high set of stresses is used and 1,100°F (593°C) when the low set of allowable stresses is used.

(d) For external pressure design, Fig. NFN-15 in Section II, Part D, shall be used.

(e) Separate welding procedure and performance qualifications shall be performed in accordance with Section IX.

(f) Postweld heat treatment is neither required nor prohibited. When heat treatment is performed, it shall be performed at 1,920°F (1050°C) minimum.

(g) This Case number shall be included in the material documentation and marking and shall be shown on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress-corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry, deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials and can result in severe underdeposit wastage and crackage. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi	Allowable Stress Values, ksi
-20 to 100	23.3	23.3
200	20.7	23.3 [Note (1)]
300	19.1	23.3 [Note (1)]
400	17.9	23.2 [Note (1)]
500	17.0	22.8 [Note (1)]
600	16.4	22.1 [Note (1)]
650	16.1	21.8 [Note (1)]
700	15.9	21.5 [Note (1)]
750	15.8	21.3 [Note (1)]
800	15.6	21.1 [Note (1)]
850	15.5	20.9 [Note (1)]
900	15.4	20.6 [Note (1)]
950	15.3	20.2 [Note (1)]
1,000	15.1	19.8 [Note (1)]
1,050	15.0	19.3
1,100	14.8	...

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 1M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa	Allowable Stress Values, MPa
-30 to 40	161	161
65	149	161 [Note (1)]
100	141	161 [Note (1)]
125	136	161 [Note (1)]
150	132	161 [Note (1)]
175	128	160 [Note (1)]
200	124	160 [Note (1)]
225	121	159 [Note (1)]
250	118	158 [Note (1)]
275	116	157 [Note (1)]
300	114	154 [Note (1)]
325	112	152 [Note (1)]
350	111	150 [Note (1)]
375	110	148 [Note (1)]
400	109	147 [Note (1)]
425	108	146 [Note (1)]
450	107	145 [Note (1)]
475	106	142 [Note (1)]
500	106	140 [Note (1)]
525	105	138 [Note (1)]
550	104	135 [Note (1)]
575	103 [Note (2)]	132 [Note (1)], [Note (2)]
600	102 [Note (2)]	...

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) This value is provided for interpolation purposes only. The maximum design temperature is as stated in (c).

Case 2527

Pneumatic Testing of Pressure Vessels, U-1(j), UM Vessels

Section VIII, Division 1

Approval Date: April 26, 2007

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may single chamber pressure vessels, fabricated by a manufacturer authorized under the provisions of Section VIII, Division 1, U-1(j), UM vessels, be routinely pneumatically tested in lieu of the provisions of UG-20(f)(2) and UG-100?

Reply: It is the opinion of the Committee that the pneumatic test provisions prescribed in UG-100 and the restrictions of UG-20(f)(2) may be waived, provided the following requirements are met:

(a) The maximum allowable working pressure of the vessel is no greater than 500 psig (3.5 MPa).

(b) The materials used for pressure retaining portions of the vessel and for nonpressure parts attached to pressure parts by welds having a throat thickness greater than $\frac{1}{4}$ in. (6 mm) are restricted to those listed in the notes to Fig. UCS-66.

(c) The following thickness limitations apply when using this Code Case:

(1) For butt joints, the nominal thickness at the thickest welded joint shall not exceed $\frac{1}{2}$ in. (13 mm).

(2) For corner joints or lap welds, the thinner of the two parts joined shall not exceed $\frac{1}{2}$ in. (13 mm).

(3) ASME B16.5 ferritic steel flanges used at design metal temperature no colder than -20°F (-29°C) may be used without thickness limitation.

(d) The minimum metal temperature during the pneumatic test shall be maintained at least 30°F (17°C) above that given in Fig. UCS-66 for the governing material classification and thickness combination in UCS-66(a).

(e) The pneumatic test pressure shall be at least equal to 1.3 times the maximum allowable working pressure, to be stamped on the vessel, multiplied by the lowest ratio (for the materials of which the vessel is constructed) of the stress value S for the test temperature of the vessel to the stress value S for the design temperature (see UG-21). In no case shall the pneumatic test pressure exceed 1.3 times the basis for calculated test pressure by more than 10% as defined in Appendix 3-2. The provisions of UG-100 shall not apply.

(f) The pressure in the vessel shall be gradually increased to not more than one-half of the test pressure. Thereafter, the test pressure shall be increased in steps of approximately one-tenth of the test pressure until the required test pressure has been reached. Then the pressure shall be reduced to a value equal to the test pressure divided by 1.3 and held for a sufficient time to permit inspection of the vessel. This inspection for leakage may be performed outside of the test facility defined in (g)(1). The visual inspection of the vessel at the required test pressure divided by 1.3 may be waived, provided:

(1) a suitable gas leak test is applied.

(2) substitution of the gas leak test is by agreement reached between Manufacturer and Inspector.

(3) all welded seams that will be hidden by assembly are given a visual examination for workmanship prior to assembly.

(4) the vessel will not be constructed and stamped for "lethal" service [see UG-116(d)].

(g) The Manufacturer is responsible for performing the pneumatic test in accordance with one of the following two options:

(1) in a test facility that is capable of containing, including the pressure wave and projectiles, a catastrophic failure of the vessel under the maximum pneumatic test pressure permitted in (e). The Manufacturer shall attest to the adequacy of such a facility by one of the following signed certifications:

(-a) For test facilities installed inside the United States or Canada, certification by a Professional Engineer experienced in the design of blast-resistant enclosures and registered in either one or more states of the United States or provinces of Canada, or;

(-b) For test facilities installed outside the United States and Canada, certification by an Engineer experienced in the design of blast-resistant enclosures with qualifications acceptable to the concerned legal jurisdiction.

The signed certification shall be identified in the written description of the Quality Control System [see UG-117(e)] for information to the Authorized Inspector as a part of the UG-117(f) authorization and annual reviews.

The Manufacturer shall ensure that the test facility is constructed and installed in accordance with the design as certified above.

(2) or the Manufacturer shall ensure the distances required by ASME PCC-2, Article 5.1, Appendices II and III are adhered to between the pressure vessel and all personnel during the pressure test.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Case 2529

Drain Valve on Horizontal Helical Coil Watertube Boilers

Section IV

Approval Date: October 27, 2005

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May a drain valve be connected at a location other than the lowest practicable water containing space on a horizontally mounted helical coil heating boiler or HLW stamped water heater?

Reply: It is the opinion of the Committee that a drain valve may be connected at a location other than the lowest practicable water containing space on a horizon-

tally mounted helical coil heating boiler or HLW stamped water heater, provided the following conditions are met:

(a) The boiler or water heater shall be a watertube type with a horizontally mounted helical coil heat exchanger.

(b) A drain valve shall be connected at the lowest practicable point in the piping connected to the heat exchanger.

(c) Helical Coil heat exchanger must be made of a corrosion resistant material.

(d) All other requirements of Section IV shall apply.

(e) This Case number shall be included on the Manufacturer's Data Report Form H-3 or Form HLW-6.

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Case 2537

Alternative Rules for Ellipsoidal or Torispherical Heads Having Integral Backing Strip Attached to Shells

Section VIII, Division 1

Approval Date: October 27, 2005

Code Cases will remain available for use until annulled by the applicable Standards Committee.

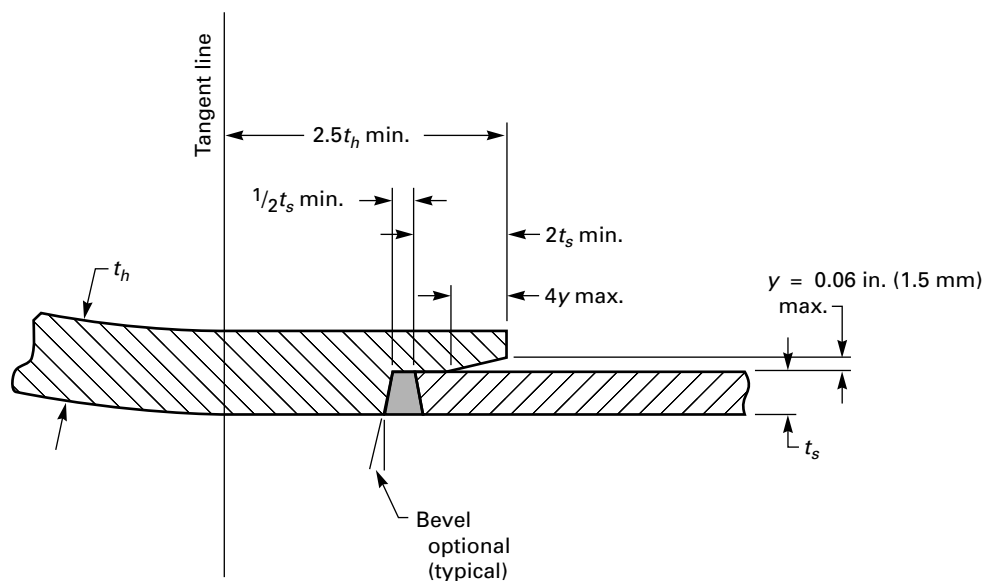
Inquiry: Under what conditions may ellipsoidal or torispherical heads having an integral backing strip be attached to shells?

Reply: It is the opinion of the Committee that an ellipsoidal or torispherical head having an integral backing strip be attached to shells provided the following requirements are met:

- (a) MAWP on the vessel shall not exceed 470 psig (1.1 MPa).
- (b) Maximum design metal temperature shall not exceed 400°F (205°C).
- (c) MDMT stamped on the nameplate shall not be colder than -20°F (-29°C).
- (d) Cyclic loading is not a controlling design requirement (see UG-22).

- (e) The vessel is not in lethal service (see UW-2).
- (f) The straight flange (skirt) of the head is machined to form an integral backing strip meeting the requirements of Figure 1.
- (g) Outside diameter of the formed head and shell shall not exceed 30 in. (750 mm).
- (h) The required thickness of the formed head shall not exceed $\frac{1}{2}$ in. (13 mm). The thickness of the head straight flange shall be at least that required for a seamless shell of the same outside diameter.
- (i) The required thickness of the shell shall not exceed $\frac{3}{16}$ in. (5 mm).
- (j) Heads shall have a driving force fit before welding.
- (k) The joint efficiency of the head-to-shell joint shall be determined from Table UW-12 for a Type 2 joint depending on the degree of radiographic examination. The limitations in Table UW-12 for the Type 2 joints do not apply.
- (l) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Integral Backing Strip



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Case 2538

Minimum Thickness of Furnace Brazed Plate Heat Exchanger Heads

Section VIII, Division 1

Approval Date: January 19, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a furnace brazed plate heat exchanger head be produced below the minimum thickness specified by UG-16?

Reply: It is the opinion of the Committee that a furnace brazed plate heat exchanger may be produced with a thickness less than that specified by UG-16 under the following conditions:

(a) The head has a minimum thickness of 0.016 in. (0.4 mm).

(b) The head is integrally brazed to and supported by a series of adjoining heat transfer plate(s).

(c) All other applicable requirements of Section VIII, Division 1 have been met.

(d) The head is protected from mechanical damage by the finned portion of the heat exchanger and by the integral underlying brazed structure.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2540-2

2.5Cr-1Mo-V-B-Ti Material

Section I

Approval Date: May 12, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 2.5Cr-1Mo-V-B-Ti (UNS K30736) seamless tubes conforming to SA-213/SA-213M, Grade T24 be used for Section I construction?

Reply: It is the opinion of the Committee that normalized and tempered seamless 2.5Cr-1Mo-V-B-Ti tubes conforming to SA-213/SA-213M, Grade T24 may be used for Section I construction, provided the following requirements are met:

(a) The wall thickness of the tubes shall not be greater than 0.5 in. (12.7 mm).

(b) The maximum design temperature shall be 1,067°F (575°C).

(c) The maximum allowable stress values for the material shall be those given in [Table 1](#) or [Table 1M](#).

(d) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. Separate welding procedure qualification is required for this material. For performance qualifications, this material shall be considered P-No. 5A. Procedure and performance qualifications qualified under previous versions of this Case do not require requalification.

(e) Exemptions to postweld heat treatment for this material shall be in accordance with the rules for P-No. 5A materials in PW-39. When postweld heat treatment is required, the time requirements shall be in accordance with the rules for P-No. 5A, and the PWHT temperature range shall be 1,325°F–1,420°F (720°C–770°C).

(f) All cold-formed material that is designed for service at a nominal temperature of 900°F (480°C) or higher shall be heat treated in accordance with the following rules. Cold-bending or -forming is defined as any method that produces strain in the material and is performed at a temperature below 1,200°F (650°C). The calculations of cold strains shall be made as described in Section I, PG-19.

(1) For tubes of diameter smaller or equal to 3 in. (76.1 mm) with greater than 28% strain, the cold-formed area, including the transition to the unstrained portion, shall be stress relieved at a temperature between 1,200°F and 1,380°F (650°C and 750°C), with

a soaking time of 1 hr/in. (1 h/25 mm), minimum of 1 hour, followed by cooling in air.

(2) For all cold swages, flares, and upsets regardless of the dimension and the amount of cold reduction, and for tubes of diameter greater than 3 in. (76.1 mm) with greater than 17% strain, the material shall be reaustenitized and tempered in accordance with SA-213/SA-213M. This heat treatment shall not be performed locally. The material shall be either heat treated in its entirety, or the cold-strained area (including the transition) shall be cut away from the balance of the tube or component, and heat treated separately or replaced.

(3) In all other cases, heat treatment is neither required nor prohibited.

(g) All material formed at or above 1,200°F (650°C) shall be reaustenitized and tempered in accordance with SA-213/SA-213M. This heat treatment shall not be performed locally. The material shall be either heat treated in its entirety, or the hot-formed area (including the transition) shall be cut away from the balance of the tube or component, and heat treated separately or replaced.

(h) Except as provided in (i), if during manufacturing any portion of the component is heated to a temperature greater than 1,420°F (770°C), then the component heated above 1,420°F (770°C), including the heat-affected zone created by the local heating, shall be removed, renormalized and tempered, and then replaced in the component.

(i) If the allowable stresses to be used are less than or equal to those provided in Table 1A in Section II, Part D for Grade 22 (SA-213/SA-213M, T22) at the design temperature, then the requirements of (h) may be waived, provided that the portion of the component heated to a temperature greater than 1,470°F (800°C) is reheat treated within the temperature range 1,325°F–1,425°F (720°C–775°C).

(j) This material is a creep strength-enhanced ferritic (CSEF) steel whose creep temperature strength is enhanced by the creation of a precise condition of microstructure, specifically martensite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbonitrides, or other stable and/or metastable phases. Refer to Section I, PW-10 for additional cautionary information.

CSEF alloys may demonstrate a susceptibility to creep-intolerant behavior, which manifests as limited amount of plastic deformation at the time of creep-rupture.

(k) This Case number shall be referenced in the documentation and marking of the material and shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Max. Allowable Stress Values, ksi
100	24.3
200	24.3
300	23.9
400	23.3
500	23.0
600	22.9
650	22.8
700	22.7
750	22.4
800	22.1
850	21.5
900	20.9
950	19.1
1,000	14.6
1,050	9.8
1,100 [Note (1)]	5.8

GENERAL NOTE: Values shown in italics are obtained from time-dependent properties.

NOTE: (1) The stress value at 1,100°F is provided for interpolation only. The maximum design is stated in (b) of the Reply.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Max. Allowable Stress Values, MPa
100	167
200	161
300	158
400	154
425	152
450	149
475	145
500	140
525	115
550	86.2
575	57.2

GENERAL NOTE: Values shown in italics are obtained from time-dependent properties.

Case 2544-2

Tolerance for Formed Heads for External Pressure Design Conditions

Section VIII, Division 1

Approval Date: January 26, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the requirements of UG-81(b) be waived?

Reply: It is the opinion of the Committee that requirements of UG-81(b) may be waived, provided the following conditions are met:

(a) t/r is greater than 0.01

where

r = outer radius

t = nominal thickness of the formed head

(b) The maximum allowable external pressure calculated in accordance with UG-33 of Division 1 is more than five times the required design external pressure.

(c) The external pressure to be stamped on the nameplate shall be no greater than 20% of the calculated maximum allowable external pressure.

(d) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2554

Alternative Method to Area Replacement Rules for Openings Under Internal Pressure

Section XII

Approval Date: January 3, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In Section XII vessels, may openings in cylindrical shells subjected to internal pressure be designed to rules other than those given in TD-610?

Reply: It is the opinion of the Committee that Section XII vessel openings in cylindrical shells subjected to internal pressure as shown in Fig. TW-140.2-1 with full penetration welds and integral reinforcement may be designed for internal pressure using the following rules instead of those given in TD-610.

(a) *Nomenclature* (See [Figure 1](#))

$$B_1 = 162 \text{ for } t_n/t \leq 1.0$$

$$= 54 \text{ for } t_n/t > 1.0$$

$$B_2 = 210 \text{ for } t_n/t \leq 1.0$$

$$= 318 \text{ for } t_n/t > 1.0$$

d_m = mean diameter of connecting pipe, (corroded condition), [see (b)(9)]

D_m = mean diameter of cylindrical vessel (corroded condition)

t_p = nominal wall thickness of connecting pipe, less corrosion allowance

t_n = nominal wall thickness of nozzle, less corrosion allowance

t = nominal wall thickness of vessel, less corrosion allowance

t_r = required thickness of vessel wall calculated per TD-300.2, with $E = 1.00$

L = axial length of nozzle with thickness t_n

$$\lambda = (d_m/D_m)(D_m/t)^{1/2}$$

t_{std} = nominal wall thickness of ASME B36.10 standard weight pipe

(b) The following conditions shall be met:

(1) Use of this Case is limited to temperatures where time-dependent properties do not control the allowable stress. See Section II, Part D, Table 1A Notes (Time-Dependent Properties).

(2) Material shall be ferrous steel with allowable stress in tension per Table 1A of Section II, Part D. The specified minimum yield strength/specified minimum tensile strength (YS/TS) shall be ≤ 0.80 .

(3) The openings shall not exceed the DN 600 (NPS 24).

(4) The ratio of opening diameter to vessel diameter (d_m/D_m) and the ratio of vessel diameter to vessel thickness (D_m/t) shall meet the following limits:

$$(-a) \text{ For } (d_m/D_m) > 0.5(D_m/t) \leq 100$$

$$(-b) \text{ For } (d_m/D_m) \leq 0.5(D_m/t) \leq 250$$

(5) Cyclic loading is not a controlling design requirement (see TD-200).

(6) The opening is in a cylindrical vessel. It shall be located not less than $1.8(D_m t)^{1/2}$ from any other gross structural discontinuity such as a head or stiffener.

(7) The spacing between the centerlines of the openings and any other opening is not less than three times their average diameter.

(8) The opening is circular in cross section and the nozzle axis is normal to the surface of the cylindrical vessel. These rules do not apply to laterals, non-uniform-wall nozzles, or pad reinforcements.

(9) If $L < 0.5(d_m t_n)^{1/2}$, use $t_n = t_p$ in [eq. \(11\)\(1\)](#) and [\(11\)\(2\)](#) below.

(10) t_n shall not be less than $\frac{7}{8} t_{std}$ through an axial length of $(d_m t_n)^{1/2}$. The other applicable rules of TD-680 shall be met.

(11) The opening shall satisfy [eqs. \(1\)](#) and [\(2\)](#), as follows:

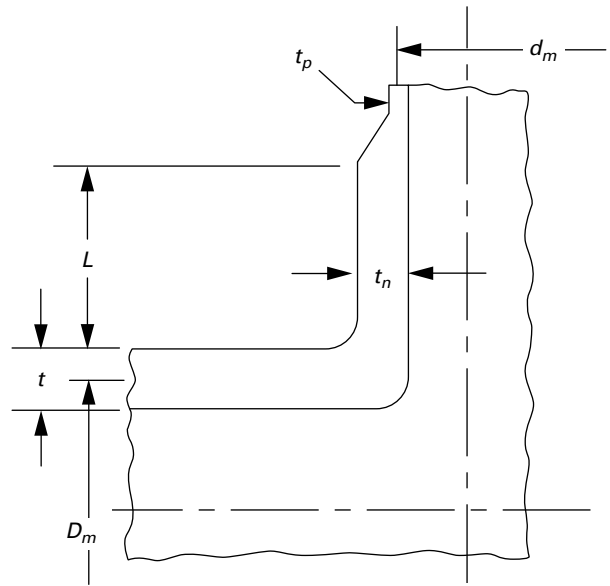
$$\frac{2 + 2\left(\frac{d_m}{D_m}\right)^{3/2} \left(\frac{t_n}{t}\right)^{1/2} + 1.25\lambda}{1 + \left(\frac{d_m}{D_m}\right)^{1/2} \left(\frac{t_n}{t}\right)^{3/2}} \leq 2.95 \left(\frac{t}{t_r}\right) \quad (1)$$

$$\frac{\left[B_1 \left(\frac{t_n}{t} \right)^2 + 228 \left(\frac{t_n}{t} \right) \left(\frac{d_m}{D_m} \right) + B_2 \right] \lambda + 155}{108 \lambda^2 + \left[228 \left(\frac{d_m}{D_m} \right)^2 + 228 \right] \lambda + 152} \geq (0.93 + 0.005 \lambda) \left(\frac{t_r}{t} \right) \quad (2)$$

(12) This Case number shall be shown on the Manufacturer's Data Report.

(c) This Code Case was developed from WRC Bulletin 335.

Figure 1



Case 2556-2

Method for Basing Design Values on Material Properties Affirmed by Material Manufacturers

Section I; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3

Approval Date: September 15, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: The European Pressure Equipment Directive (PED) has provisions that require the values used in the design of pressure equipment to be based on material properties affirmed by the material manufacturer. By what rules are the values provided in the ASME Boiler and Pressure Vessel Code related to the properties affirmed by the material manufacturer in accordance with the requirements of the applicable SA/SB specification?

Reply: It is the opinion of the Committee that the values provided in the ASME Boiler and Pressure Vessel Code that are used in the design of boilers and pressure vessels are based on the properties affirmed by the material manufacturer (in accordance with the requirements of the applicable SA/SB specification) according to the following:

(a) Mandatory references¹ to Code Sections that contain values to be used in the design of boilers and pressure vessels are listed below.

- (1) Section I
- (2) Section VIII, Division 1
- (3) Section VIII, Division 2
- (4) Section VIII, Division 3
- (5) Section II, Part D

NOTE: All requirements for the above referenced standards shall also be met.

(b) A description of the method for determining the values provided in the ASME Boiler and Pressure Vessel Code that are used in the design of boilers and pressure vessels and based on the properties affirmed by the material manufacturer (in accordance with the requirements of the applicable SA/SB specification) is provided in Mandatory Appendices 1 through 5 and 10 of Section II, Part D.

(c) Material test reports shall be obtained from the material manufacturer for all materials and contain an affirmation that the material complies with the stated specification.

(d) When invoked, this Code Case is a supplement to each of the SA/SB specifications listed on the Manufacturer's Data Report as required by (e).

(e) This Case number and an itemized list of the material specifications to which it applies shall be shown on the Manufacturer's Data Report.

¹ Within European standards, references to other standards that give the named standard the same status as the host are referred to as Normative References.

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Case 2563

Aluminum Alloy, UNS A96061 Temper T6 and UNS A96061 Temper T651

Section VIII, Division 3

Approval Date: December 30, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May Aluminum Alloy, UNS A96061 Temper T6 and UNS A96061 Temper T651 be used for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that A96061-T6 and A96061-T651 aluminum may be used for the construction of Section VIII, Division 3 components, provided the following conditions are satisfied:

(a) Materials shall conform to the specifications listed in [Table 1](#) and shall not exceed 3 in. (75 mm) in thickness.

(b) Vessels may be manufactured from O and F temper material from sheet, plate bar, rod, drawn seamless tube, and seamless extruded tube conforming to [Table 1](#) specification. Finished vessels shall be heat treated in accordance with the requirements of the specifications listed in [Table 1](#) and shall meet the specified mechanical properties for T6 or T651 temper, as applicable.

(c) Material shall be qualified by the following notch tensile test for T6 or T651 temper.

(1) The Sharp-Notch Strength/Yield Strength Ratio shall be determined using the ASTM E338 or ASTM E602 test method. Specimens shall be cut from a production vessel. Two specimens from a production vessel shall be tested to qualify a single heat of material. The samples shall be obtained from the production vessel after the all forming and heat treating is completed.

(2) The geometry of the specimen shall meet the dimensional requirement of ASTM E338, para. 6, Fig. 3 or ASTM E602, Figure 1. The specimen shall be cut such that the longitudinal axis of the production vessel is parallel to the long axis of the specimen. The following exemptions to the dimensional requirements of the above specimens may be applied:

(-a) For ASTM E338 specimen, the test section width less than 2 in. (50 mm) may be used, however the ratio of the notch depth to specimen net ligament width shall not be less than 0.25. The specimen thickness limitation in the test section need not be satisfied.

(-b) For ASTM E602 specimen, the test section diameter less than 0.5 in. (12.5 mm) may be used, however the ratio of notch depth to the specimen net ligament diameter shall not be less than 0.25.

(3) The tensile test methods in ASTM B557 shall be used in lieu of ASTM E8 where specified in ASTM E338 and ASTM E602.

(4) Sharp-Notch Strength/Yield Strength Ratio shall not be less than 0.9.

(d) Maximum metal temperature shall not exceed 225°F (107°C).

(e) Yield strength values shall be as shown in [Table 2](#), [Table 2M](#), [Table 3](#), and [3M](#).

(f) The following properties shall be used in the fracture mechanics evaluation. The material is exempted from Charpy V Notch testing requirements.

(1) A value of 23 ksi – in.^{1/2} (25 MPa–m^{1/2}) shall be used for critical, or reference, stress intensity factor.

(2) The fatigue crack growth rate and threshold stress-intensity properties given in KD-430 shall be used with the following values of the constants:

(-a) U.S. Customary units:

$$C = 7.01 \text{ E-}9 \text{ (in./cycle)(ksi-in.}^{1/2}\text{)}^{-m}$$

$$m = 3.26$$

$$G = 2.13 \text{ ksi-in.}^{1/2}$$

$$I = 1.83 \text{ ksi-in.}^{1/2}$$

$$\Delta K_{th} \text{ need not be less than } 0.67 \text{ ksi – in.}^{1/2}.$$

(-b) SI units:

$$C = 1.31 \text{ E-}10 \text{ (m/cycle)(MPa-m}^{1/2}\text{)}^{-m}$$

$$m = 3.26$$

$$G = 2.34 \text{ MPa-m}^{1/2}$$

$$I = 2.01 \text{ MPa-m}^{1/2}$$

$$\Delta K_{th} \text{ need not be less than } 0.73 \text{ MPa – m}^{1/2}.$$

(g) All other requirements of Section VIII, Division 3 shall apply.

(h) The fatigue design data given in [Figure 1](#) or [1M](#) or in [Table 4](#) shall be used in the fatigue evaluation.

(i) Welding and thermal cutting are not permitted.

(j) The tensile test methods (ASTM B557) required in the product specifications in [Table 1](#) shall be used in lieu of SA-370 as specified in KM-232.

(k) This Case number shall be shown on the Manufacturer's Data Report.

**Table 1
Product Specifications**

Specification Number	UNS Number	Product Form
SB-209, T6 or T651 temper	A96061	Sheet and plate
SB-210, T6 temper	A96061	Drawn seamless tube
SB-221, T6 temper	A96061	Bars, rods and profiles
SB-241/SB-241M, T6 temper	A96061	Seamless extruded tubes
SB-308/SB-308M, T6 temper	A96061	Bar, rod, shapes

**Table 2
Yield Strength Values, A96061 Aluminum — T6 Temper**

Material Specification (Thickness)	Specified Yield Strength, ksi	Specified Minimum Yield Strength Values for Metal Temperature, °F			
		-20 to 100	150	200	250 [Note (1)]
SB-209 Sheet, Plate (0.051 in. to 0.249 in.)	35	35	34.6	33.7	32.4
SB-210 Drawn, seamless tube (0.025 in. to 0.500 in.)	35	35	34.6	33.7	32.4
SB-221 Bar, rod, shapes	35	35	34.6	33.7	32.4
SB-308 Shapes	35	35	34.6	33.7	32.4

NOTE: (1) These values are provided for extrapolation only. The maximum design temperature is 225°F.

**Table 2M
Yield Strength Values, A96061 Aluminum — T6 Temper**

Material Specification (Thickness)	Specified Yield Strength, MPa	Specified Minimum Yield Strength Values for Metal Temperature, °C			
		-30 to 40	65	100	125 [Note (1)]
SB-209 Sheet, plate (1.30 mm to 6.34 mm)	241	241	239	231	220
SB-210 Drawn, seamless tube (0.64 mm to 12.7 mm)	241	241	239	231	220
SB-221 Bar, rod, shapes	241	241	239	231	220
SB-241 Seamless extruded tube	241	241	239	231	220
SB-308 Shapes	241	241	239	231	220

NOTE: (1) These values are provided for extrapolation only. The maximum design temperature is 107°C.

Table 3
Yield Strength Values, A96061 Aluminum — T651 Temper

Material Specification (Thickness)	Specified Yield Strength, ksi	Specified Minimum Yield Strength Values for Metal Temperature, °F			
		-20 to 100	150	200	250 [Note (1)]
SB-209 Sheet, plate (0.25 in. to 4.000 in.)	35	35	34.6	33.7	32.4
SB-209 Sheet, plate (4.001 in. to 6.000 in.)	35	35	34.6	33.7	32.4

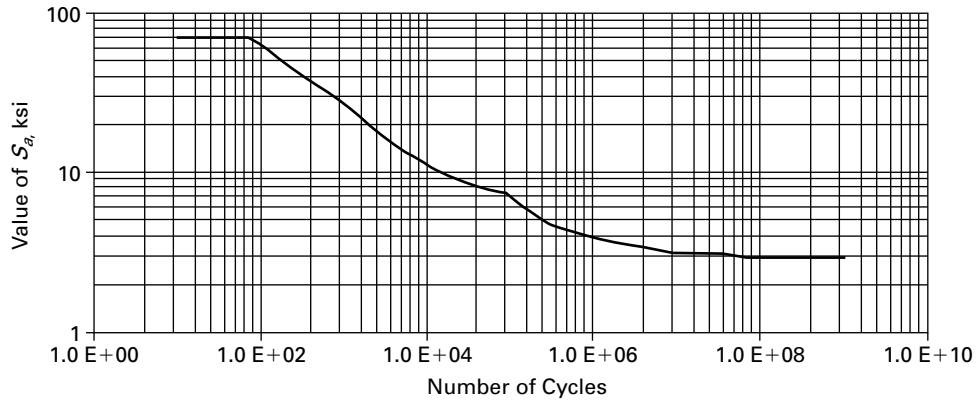
NOTE: (1) These values are provided for extrapolation only. The maximum design temperature is 225°F.

Table 3M
Yield Strength Values, A96061 Aluminum — T651 Temper

Material Specification (Thickness)	Specified Yield Strength, MPa	Specified Minimum Yield Strength Values for Metal Temperature, °C			
		-30 to 40	65	100	125 [Note (1)]
SB-209 Sheet, plate (6.34 mm to 100 mm)	241	241	239	231	220
SB-209 Sheet, plate (101 mm to 150 mm)	241	241	239	231	220

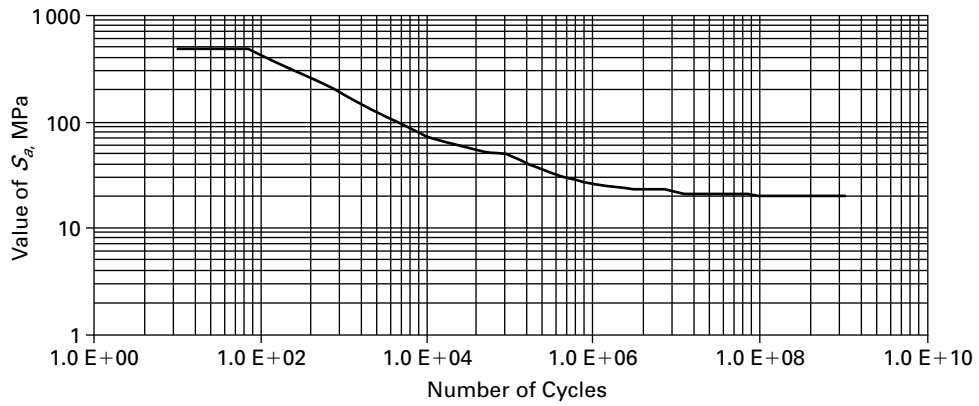
NOTE: (1) These values are provided for extrapolation only. The maximum design temperature is 107°C.

Figure 1
Design Fatigue Curve for Nonwelded 6061-T6 Aluminum Construction



GENERAL NOTE: Modulus of elasticity - $E = 10 \times 10^6$ psi.

Figure 1M
Design Fatigue Curve for Nonwelded 6061-T6 Aluminum Construction



GENERAL NOTE: Modulus of elasticity - $E = 69 \times 10^3$ MPa.

Table 4
Tabulated Values of S_a Alternating Stress Intensity from
Figures 1 and 1M

N, Number of Cycles	S_a With Maximum Mean Stress, ksi	S_a With Maximum Mean Stress, MPa
1.0E+01	70.00	483
2.0E+01	70.00	483
5.0E+01	70.00	483
7.0E+01	70.00	483
1.0E+02	60.96	420
2.0E+02	47.20	325
5.0E+02	34.80	240
1.0E+03	26.79	185
2.0E+03	20.00	138
5.0E+03	13.78	95
7.0E+03	12.40	85
1.0E+04	10.93	75
2.0E+04	9.14	63
5.0E+04	7.74	53
9.0E+04	7.18	50
1.0E+05	6.89	48
2.0E+05	5.47	38
5.0E+05	4.36	30
1.0E+06	3.87	27
2.0E+06	3.55	24
5.0E+06	3.29	23
1.0E+07	3.16	22
2.0E+07	3.07	21
5.0E+07	3.00	21
1.0E+08	2.96	20
2.0E+08	2.93	20
5.0E+08	2.91	20
1.0E+09	2.90	20

GENERAL NOTES:

- (a) Number of design cycles indicated shall be as follows: $1.0E + J = 1 \times 10^J$, e.g., $5.0E + 2 = 5 \times 10^2$
- (b) Interpolation between tabular values is permissible based upon data representation by straight lines on a log-log plot. Accordingly, for $S_i > S > S_j$, $(N/N_i) = (N_j/N_i)^{[\log(S_i/S)/\log(S_i/S_j)]}$

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Case 2565

Mounting Safety and Safety Relief Valves for Coil Type Heating Boilers

Section IV

Approval Date: December 30, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Section IV, HG-701.1 requires that coil type boilers shall have the safety valve or safety relief valves located on the steam or hot water outlet end. Under what circumstances is it permissible to mount safety or safety relief valves downstream of the outlet end of the heated tubing in coil type boilers?

Reply: It is the opinion of the Committee that it is permissible to mount safety and safety relief valves downstream of the outlet end of the heated tubing of coil type boilers under the following conditions:

(a) The safety or safety relief valves cannot be isolated from the heated tubing.

(b) The water volume contained in the heated tubing and the pipe or tubing connecting the heated tubing and the safety or safety relief valve shall not exceed 1 gal (3.8 L).

(c) The tubing and outlet tubing or piping shall not exceed NPS 1 (DN 25) diameter.

(d) This Case number shall be included on the Manufacturer's Data Report.

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Case 2568-1

HG-701.1 Permissible Mounting Safety Relief Valves for Coil-Type Water Boilers

Section IV

Approval Date: December 21, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Section IV, HG-701.1 requires that a coil-type water boiler shall have the safety relief valve located on the hot water outlet end. Under what circumstances is it permissible to mount the safety relief valve on the header between the primary and secondary heat exchangers of a coil-type water boiler?

Reply: It is the opinion of the Committee that it is permissible to mount the safety relief valve on the header between the primary and secondary heat exchangers of a coil-type water boiler under the following conditions:

(a) The system circulator is installed on the hot water outlet piping.

(b) There are no intervening valves between the primary heat exchanger, secondary heat exchanger or safety relief valve.

(c) The water volume contained in the heated tubing and the piping and the safety relief valve shall not exceed 3 gal (11.4 L).

(d) A flow-sensing device is installed on the hot water outlet end of the coil-type water boiler to prevent burner operation at a water flow rate inadequate to protect the water boiler unit against overheating at all allowable firing rates.

(e) Temperature-sensing devices are installed on the cold inlet and hot outlet water ends of the coil-type water boiler for high temperature limit protection.

(f) The safety relief valve shall be placed at a location where the highest operating pressure occurs.

(g) All other requirements of Section IV shall apply.

(h) This Case number shall be included on the Manufacturer's Data Report.

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Case 2571-1

Use of SA-240, Grades 304L and 316L in Thickness Less Than $\frac{1}{4}$ in. (6 mm)

Section IV

Approval Date: January 26, 2009

Impending Annulment Date: January 1, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-240 Plate Alloy Steel, Grades 304L and 316L in thickness less than $\frac{1}{4}$ in. (6 mm) be used in Section IV construction?

Reply: It is the opinion of the Committee that SA-240 Plate Alloy Steel, Grades 304L and 316L in thickness less than $\frac{1}{4}$ in. (6 mm) may be used in Section IV construc-

tion for maximum allowable working pressures up to 160 psi, provided:

(a) The material shall be used only on hot water heating boilers or hot water supply boilers.

(b) The material thickness shall not be less than 0.059 in. (1.5 mm).

(c) The material shall be limited to headers not exposed to products of combustion.

(d) All other requirements of Section IV shall apply.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2576

Use of ASTM A672-06 and A691-98(R2002) Electric-Fusion-Welded Pipe

Section I

Approval Date: December 30, 2006

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May electric fusion welded (EFW) pipe made to ASTM A672-06 and ASTM A691-98(R2002) be used in Section I construction?

Reply: It is the opinion of the Committee that electric fusion welded pipe may be used in Section I construction under the following conditions:

(a) The electric fusion welded pipe shall be limited to those specifications, grades, and classes given in [Table 1](#).

(b) Allowable stresses to be used shall be those given in Table 1A of Section II Part D for Section I use for the equivalent ASME materials (as shown in [Table 1](#)), and design temperatures shall be limited to those given in [Table 1](#).

(c) Material Test Reports (MTRs) shall be provided for the plate used in making the pipe and for all tests required to be performed in manufacturing the pipe.

(d) The welding filler metal used shall have the same nominal composition as the base metal.

(e) The P and/or S numbers to be used in welding these materials shall be the same as the P numbers of the equivalent ASME plate material specifications given in [Table 1](#).

(f) This Case number shall be identified in the MTR.

(g) This Case number shall be included in the Manufacturer's Data Report.

Table 1
Pipe Specifications

ASTM Specification	Plate Material Specification	Maximum Use Temperature, °F (°C)
A672-C60 Cl. 22	SA-516 Gr. 60	700 (371)
A672-C65 Cl. 22	SA-516 Gr. 65	700 (371)
A672-C70 Cl. 22	SA-516 Gr. 70	700 (371)
A672-N75 Cl. 22	SA-299	700 (371)
A672-H80 Cl. 22	SA-302 Gr. C	800 (427)
A691-1Cr Cl. 22	SA-387 Gr. 12 Cl. 1	850 (454)
A691-1Cr Cl. 22	SA-387 Gr. 12 Cl. 2	850 (454)
A691-1½Cr Cl. 22	SA-387 Gr. 11 Cl. 1	850 (454)
A691-1½Cr Cl. 22	SA-387 Gr. 11 Cl. 2	850 (454)
A691-2½Cr Cl. 22	SA-387 Gr. 22 Cl. 1	850 (454)
A691-2½Cr Cl. 22	SA-387 Gr. 22 Cl. 2	850 (454)
A691-91 Cl. 42	SA-387 Gr. 91 Cl. 2	1,000 (538)

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Case 2577

Use of 316L Stainless Steel at Elevated Temperatures

Section VIII, Division 1

Approval Date: October 2, 2008

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May Type 316L (UNS S31603) material conforming to material specifications SA-182, SA-213/SA-213M, SA-240, SA-249, SA-312, SA-336, SA-403, or SA-479 be used in the construction of welded vessels designed to Section VIII, Division 1, at 850°F to 1200°F (454°C to 649°C)?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used for welded construction under the rules of Section VIII, Division 1 within the limits listed in the Inquiry, provided the following requirements are met:

(a) The allowable stresses shall be obtained from [Tables 1](#) and [1M](#).

(b) The material shall have an ASTM grain size of 7 or coarser for use at 1,000°F (550°C) and above.

(c) This Case number shall be identified on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)] and [Note (2)]
900	9.2, 12.4 [Note (3)]
950	9.0, 12.1 [Note (3)]
1,000	8.8, 11.9 [Note (3)]
1,050	8.6, 11.6 [Note (3)]
1,100	8.4, 11.4 [Note (3)]
1,150	8.3, 8.8 [Note (3)]
1,200	6.4, 6.4

GENERAL NOTE: Material sensitized by exposure to long-time high-temperature operation may have reduced low-temperature notch toughness.

NOTES:

- (1) Stress values for welded pipe and tube shall be the listed values multiplied by a factor of 0.85.
- (2) Allowable stresses for temperatures of 1200°F and above are values obtained from time-dependent properties.
- (3) Due to the relatively low yield strength of these materials, these high stress values were established at temperatures where the short-time tensile properties govern to permit use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)] and [Note (2)]
525	61.2, 82.6 [Note (3)]
550	59.9, 80.9 [Note (3)]
575	58.8, 79.4 [Note (3)]
600	57.8, 76.5 [Note (3)]
625	57.0, 58.5 [Note (3)]
650	43.4, 43.4 [Note (4)]

GENERAL NOTE: Material sensitized by exposure to long-time high-temperature operation may have reduced low-temperature notch toughness.

NOTES:

- (1) Stress values for welded pipe and tube shall be the listed values multiplied by a factor of 0.85.
- (2) Allowable stresses for temperatures of 650°C and above are values obtained from time-dependent properties.
- (3) Due to the relatively low yield strength of these materials, these high stress values were established at temperatures where the short-time tensile properties govern to permit use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (4) Maximum design temperature is 649°C. Value at 650°C is provided for interpolation only.

Case 2581

20Cr-25Ni-1.5Mo-Cb-N Seamless Austenitic Stainless Steel Tube

Section I

Approval Date: April 26, 2007

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-treated 20Cr-25Ni-1.5Mo-Cb-N seamless austenitic stainless steel tube with chemical analysis shown [Table 1](#), the mechanical properties shown in [Table 2](#), and that otherwise conform to applicable requirements in SA-213/SA-213M be used for steam service in Section I construction?

Reply: It is the opinion of the Committee that the material listed in the Inquiry may be used for steam service in Section I construction, provided that the following requirements are met:

(a) The material shall meet the chemical analysis and minimum tensile requirements specified in [Tables 1](#) and [2](#), and shall otherwise meet the requirements of SA-213/SA-213M as applicable, except as shown in [\(b\)](#) and [\(c\)](#).

(b) The minimum solution treating temperature for this material shall be 2,100°F (1 150°C).

(c) This material shall have a hardness not exceeding 256 HB/270 HV (100 HRB).

(d) The rules of PG-19 for TP347H shall apply for this material, except that solution treatment, when required, shall be at the minimum temperature of 2,100°F (1 150°C).

(e) The maximum allowable stress values for the material shall be as given in [Tables 3](#) and [3M](#). The maximum design temperature is 1,500°F (815°C).

(f) Separate welding procedure and performance qualification shall be conducted for the material in accordance with Section IX. Filler metal shall be limited to either nickel-base fillers SFA-5.14 class ERNiCrMo-3 (Alloy 625) or to matching filler metal.

NOTE: When nickel-base fillers SFA-5.14 class ERNiCrMo-3 (Alloy 625) is used, the weld metal is subject to severe loss of impact strength at room temperature after exposure in the range of 1,000°F to 1,400°F (540°C to 760°C).

(g) This Case number shall be referenced in the documentation and marking of the material and recorded on the Manufacture's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon, max.	0.10
Manganese, max	1.50
Phosphorus, max.	0.030
Sulfur, max.	0.030
Silicon, max.	1.00
Nickel	23.0–26.0
Chromium	19.5–23.0
Molybdenum	1.0–2.0
Nitrogen	0.10–0.25
Columbium	0.10–0.40
Titanium, max.	0.20
Boron	0.002–0.010

Table 2
Mechanical Property Requirements

Tensile strength, min. ksi (MPa)	93 (640)
Yield strength, min. ksi (MPa)	39 (270)
Elongation in 2 in. or 50 mm, min. %	30

Table 3
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi
-40 to 100	26.0, 26.0
200	22.1, 26.0 [Note (1)]
300	20.5, 25.5 [Note (1)]
400	19.5, 24.7 [Note (1)]
500	18.8, 24.1 [Note (1)]
600	18.2, 24.1 [Note (1)]
650	17.9, 24.1 [Note (1)]
700	17.6, 23.7 [Note (1)]
750	17.2, 23.3 [Note (1)]
800	16.9, 22.9 [Note (1)]
850	16.6, 22.5 [Note (1)]
900	16.4, 22.1 [Note (1)]
950	16.1, 21.8 [Note (1)]
1,000	15.9, 21.5 [Note (1)]
1,050	15.7, 21.2 [Note (1)]
1,100	15.6, 19.0 [Note (1)]
1,150	14.9, 14.9
1,200	11.9, 11.9
1,250	9.6, 9.6
1,300	7.8, 7.8
1,350	6.3, 6.3
1,400	5.1, 5.1
1,450	4.1, 4.1
1,500	3.2, 3.2

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) Due to the relatively low yield strength of this material, these high stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 3M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa
-30 to 40	180, 180
65	161, 180 [Note (1)]
100	151, 180 [Note (1)]
125	145, 179 [Note (1)]
150	141, 176 [Note (1)]
200	135, 171 [Note (1)]
250	130, 168 [Note (1)]
300	126, 167 [Note (1)]
325	125, 167 [Note (1)]
350	123, 166 [Note (1)]
375	121, 163 [Note (1)]
400	119, 160 [Note (1)]
425	117, 158 [Note (1)]
450	115, 155 [Note (1)]
475	113, 153 [Note (1)]
500	112, 151 [Note (1)]
525	110, 149 [Note (1)]
550	109, 147 [Note (1)]
575	108, 146 [Note (1)]
600	107, 123 [Note (1)]
625	99.3, 99.3
650	81.4, 81.4
675	67.1, 67.1
700	55.5, 55.5
725	46.0, 46.0
750	38.1, 38.1
775	31.2, 31.2
800	25.4, 25.4
825	20.2, 20.2 [Note (2)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only.

Case 2585-1

23Cr-35Ni-7.5Mo-N, UNS N08354, Austenitic Alloy

Section VIII, Division 1

Approval Date: September 15, 2009

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 23Cr-35Ni-7.5Mo-N, UNS N08354, austenitic alloy sheet, strip, plate, pipe, tube, and bar, meeting the chemical composition and mechanical property requirements shown in [Tables 1 and 2](#), and otherwise conforming to one of the specifications in [Table 3](#), be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section VIII, Division 1 construction, provided the following requirements are met:

(a) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for nickel alloys.

(b) For external pressure, use Fig. HA-6 of Section II, Part D.

(c) The maximum allowable stress values for the material shall be those given in [Tables 4 and 4M](#). For welded pipe and tube products, a joint efficiency of 0.85 shall be used.

(d) Maximum design temperature of the material shall be 800°F (427°C).

(e) Separate welding procedure and performance qualifications shall be conducted for the material in accordance with Section IX. When welding this material to itself, GTAW welding process welded with ERNiCrMo-4 (UNS N10276) or similar corrosion resistant weld filler metals shall be used.

(f) Heat treatment after forming or fabrication is neither required nor prohibited. However, if heat treatment is applied, the solution annealing treatment shall be as noted in [\(g\)](#).

(g) The material shall be furnished in the solution annealed condition at a temperature range from 1975°F to 2155°F (1080°C to 1180°C) followed by rapid cooling in air or water.

(h) This Case number shall be shown on the documentation, marking of the material, and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon, max.	0.030
Manganese, max	1.00
Phosphorus, max.	0.030
Sulfur, max.	0.010
Silicon, max.	1.00
Nickel	34.00–36.00
Chromium	22.00–24.00
Molybdenum	7.0–8.0
Nitrogen	0.17–0.24

Table 2
Mechanical Property Requirements

Tensile strength, min. ksi (MPa)	93 (640)
Yield strength, min. ksi (MPa)	43 (295)
Elongation in 2 in. or 50 mm, min. %	40
Hardness HRB (HB), max.	96 (217)

Table 3
Product Specifications

Bar and wire	SB-649
Seamless pipe and tube	SB-677
Sheet, strip, and plate	SB-625
Welded pipe	SB-673

Table 4
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi
100	26.5, 26.5
200	24.3, 26.5 [Note (1)]
300	22.1, 25.0 [Note (1)]
400	20.5, 23.8 [Note (1)]
500	19.6, 23.0 [Note (1)]
600	18.9, 22.5 [Note (1)]
650	18.6, 22.3 [Note (1)]
700	18.3, 22.1 [Note (1)]
750	18.0, 21.9 [Note (1)]
800	17.7, 21.7 [Note (1)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) Due to the relatively low yield strength of this material, these high stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 4M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, Max., MPa
40	183, 183
65	178, 183 [Note (1)]
100	166, 182 [Note (1)]
125	158, 177 [Note (1)]
150	152, 172 [Note (1)]
200	142, 165 [Note (1)]
250	136, 160 [Note (1)]
300	132, 156 [Note (1)]
325	130, 155 [Note (1)]
350	128, 154 [Note (1)]
375	126, 152 [Note (1)]
400	124, 151 [Note (1)]
425	122, 150 [Note (1)]
450	121, 148 [Note (1)], [Note (2)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only. The maximum use temperature is 800°F (427°C).

Case 2587

Alternative Rules for Designing U-Shaped Bellows

Section VIII, Division 1

Approval Date: August 6, 2007

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the rules of Section VIII, Division 1, Appendix 26 be used to design bellows expansion joints with U-shaped convolutions having a torus radius, r_i , less than three times the bellows thickness, t ?

Reply: It is the opinion of the Committee that the rules of Section VIII, Division 1, Appendix 26 may be used to design bellows expansion joints with U-shaped convolutions having a torus radius, r_i , less than three times the bellows thickness, t , provided the following:

- (a) The rules of 26-4.2(b) are followed.
- (b) The increasing bending stress due to curvature is accounted for in the correlation testing.
- (c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2588

Ni-Cr-Mo Bolting Material UNS N06059, ASTM F468-06

Section VIII, Division 1

Approval Date: October 19, 2007

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May cold-worked/strain-hardened or annealed alloy UNS N06059 bars up to 4.00 in. diameter conforming to ASTM F468-06 be employed for bolting materials up to 700°F (371°C) for code applications?

Reply: It is the opinion of the Committee that cold-worked/strain-hardened bars as described in the Inquiry may be employed for bolting applications.

(a) The maximum allowable stresses for the four different grades of alloy UNS N06059 per ASTM F468-06 shall be as shown in Table 1 and Table 1M.

(b) No welding, weld repair, or any thermal treatment shall be permitted on the cold-reduced/strain-hardened bars.

(c) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values, ksi

Grade / Condition	Metal Temperature Not Exceeding, °F						
	100	200	300	400	500	600	700
Ni 59 Grade 1 (cold worked)	25.0	25.0	25.0	23.8	22.6	21.4	21.3
Ni 59 Grade 2 (cold worked)	27.0	27.0	27.0	27.0	27.0	27.0	27.0
Ni 59 Grade 3 (cold worked)	32.0	32.0	32.0	32.0	32.0	32.0	32.0
Ni 59 Grade 4 (annealed)	25.0	25.0	25.0	23.8	22.6	21.4	20.2

Table 1M
Maximum Allowable Stress Values, MPa

Grade / Condition	Metal Temperature Not Exceeding, °C										
	40	65	100	125	150	200	250	300	325	350	375 [Note (1)]
Ni 59 Grade 1 (cold worked)	172	172	172	172	172	165	157	150	147	146	146
Ni 59 Grade 2 (cold worked)	186	186	186	186	186	186	186	186	186	186	186
Ni 59 Grade 3 (cold worked)	221	221	221	221	221	221	221	221	221	221	221
Ni 59 Grade 4 (annealed)	172	172	172	172	172	169	164	150	146	143	139

NOTE: (1) This value is provided for interpolation purposes only.

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Case 2594-2

Use of SA/EN 10028-3, Grade P460NL1, Fine Grain Normalized Steel Plates for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may steel plates, manufactured in accordance with SA/EN 10028-3, Grade P460NL1 be used in Section VIII, Division 2, Class 2 construction?

Reply: It is the opinion of the Committee that steel plates, manufactured in accordance with SA/EN 10028-3, Grade P460NL1, may be used in Section VIII, Division 2, Class 2 construction, provided the following additional requirements are met:

(a) The thickness of the plates shall not exceed 0.79 in. (20 mm).

(b) The chemical composition shall conform to the values listed in SA/EN 10028-3 for Grade P460NL1, except that:

(1) The copper content shall not exceed 0.20% by heat analysis.

(2) The vanadium content shall be within the range of 0.10% to 0.20% by heat analysis.

(c) The design temperature shall not exceed 150°F (65°C).

(d) The specified minimum tensile strength shall be 91.5 ksi (630 MPa).

(e) The yield strength values shall be those listed in Table 1.

(f) The design stress intensity, S_m , shall be 38.14 ksi (263 MPa).

(g) For external pressure design, the requirements of Fig. CS-5 of Section II, Part D shall apply.

(h) The provisions for impact test exemption in paras. 3-11.2.3 through 3-11.2.5 shall not apply.

(i) For the purpose of postweld heat treatment, the material shall be considered as P-No. 10A, Gr. 1, except that:

(1) Postweld heat treatment shall be in the temperature range of 985°F to 1,040°F (530°C to 560°C) with a minimum holding time of ½ hr at temperature.

(2) Consideration should be given for possible embrittlement when postweld heat treating the material and welded joints.

(j) Separate welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(k) Welding by electroslag or electrogas process is not permitted.

(l) This Case number shall be marked on the material, documented on the material test report, and shown on the Manufacturer's Data Report.

Table 1
Values of Yield Strength

Thickness, t , in. (mm)	Yield Strength, ksi (MPa), For Metal Temperature Not Exceeding, °F (°C)	
	100 (40)	150 (65)
$t \leq \frac{5}{8}$ in. (16 mm)	66.5 (460)	64.5 (445)
$\frac{5}{8}$ in. (16 mm) < $t \leq 0.79$ in. (20 mm)	64.5 (445)	62.5 (430)

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Case 2595

Use of Materials in a Current Code Edition for a Boiler Constructed to an Earlier Code Edition

Section I

Approval Date: January 4, 2008

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May materials in the current Code Edition and Addenda of Section I be used in a boiler to be constructed to an earlier Code Edition and Addenda of Section I that did not include those materials?

Reply: It is the opinion of the Committee that that materials in the current Code Edition and Addenda of Section I may be used in a boiler to be constructed to an earlier Code Edition and Addenda of Section I that did not include those materials, provided the following additional requirements are met:

(a) The maximum allowable stress values in the current Code Edition and Addenda are the unit stresses to be used in the formulas of the current Code Edition and

Addenda to calculate the minimum required thickness or the maximum allowable working pressure of the pressure part.

(b) Miscellaneous pressure parts shall comply with the requirements of PG-11 of the current Code Edition and Addenda.

(c) The applicable welding requirements in the current Code Edition and Addenda shall be applied for the material and welding processes.

(d) The base material, post-weld, and post-forming heat treatment requirements in the current Code Edition and Addenda shall be applied for the material.

(e) All other Code requirements of the earlier Code Edition and Addenda to be used for final certification of the completed boiler shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2596-1

Cold-Stretching of Austenitic Stainless Steel Pressure Vessels

Section VIII, Division 1

Approval Date: April 6, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May cold-stretched austenitic stainless steel pressure vessels be constructed under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that cold-stretched austenitic stainless steel vessels may be constructed under the rules of Section VIII, Division 1, provided the following additional requirements are met.

1 SCOPE

(a) Vessel wall thickness shall not exceed 1.2 in. (30 mm).

(b) Minimum metal design temperature (MDMT) shall not be colder than -320°F (-196°C).

(c) Maximum design temperature shall not exceed 120°F (50°C).

(d) Pressure vessels designed using the rules specified in this Case are limited to single diameter cylindrical shells with dished heads, spherical shells, and nozzles without reinforcing pad.

(e) The minimum specified ultimate tensile strength (UTS) of the weld filler metal used in construction shall not be less than the minimum specified UTS for the base metals of the weld joint.

(f) Nozzles and opening reinforcement components shall be designed using Section VIII, Division 1 rules, and applying the allowable stress values specified in Section II, Part D.

(g) The rules specified in this Case are applicable for vessels designed for internal pressure only, and shall not be used for vessels designed for external pressure.

(h) Nozzle size shall not exceed NPS 6 (DN 150) in shells and heads and NPS 8 (DN 200) at the center of the heads.

(i) All Category A weld joints shall be Type No. 1. All Category B weld joints shall be Type No. 1 or Type No. 2.

2 NOMENCLATURE

P = design pressure

P_c = coldstretch pressure

S = allowable design stress in tension

Y_c = yield strength in the coldstretched condition

3 MATERIALS AND ALLOWABLE DESIGN STRESS

The stainless steel materials listed in Table 1 are allowed in the vessel construction. The value of allowable design stress S in tension shall not exceed the value listed in Table 1.

4 DESIGN

(a) Wall thicknesses shall be calculated according to the applicable rules of Section VIII, Division 1 before cold-stretching. The maximum design stress value shall be as shown in Table 1.

(b) Nominal diameters may be used in the design calculations. No allowance is necessary for the possible increase in diameter due to cold-stretching.

(c) The cold-stretching pressure P_c shall not be less than 1.5 times the design pressure P and shall not be greater than 1.6 times the design pressure.

(d) Inside knuckle radius of formed torispherical heads shall not be less than 10% of the inside crown radius of the head.

(e) Butt welded joints shall be fully radiographed per UW-51 or examined by ultrasonic examination using Code Case 2235.

(f) All nozzles shall be attached with full penetration welds.

(g) The thickness of a support pad shall not exceed the thickness of the shell at the attachment location.

(h) Full thickness fillet welds shall be provided at support pad attachment locations.

5 FABRICATION PROCESS

5.1 WELDING AND EXAMINATION

(a) For all Category A joints, the reinforcement shall not exceed 10% of the plate thickness or $\frac{1}{8}$ in. (3 mm), whichever is less. The edge of the weld deposits shall merge smoothly into the base metal without undercut or abrupt transition. All attachment welds shall be

Table 1
Allowable Materials and Design Stress

Material	Allowable Design Stress S in Tension, ksi	Allowable Design Stress S in Tension, MPa
SA-240, Type 304 Stainless steel	39.3	270
SA-240, Type 304L Stainless steel	36.0	247
SA-240, Type 304N Stainless steel	42.7	293
SA-240, Type 316 Stainless steel	39.3	270
SA-240, Type 316L Stainless steel	36.0	247
SA-240, Type 316N Stainless steel	42.7	293
SA-240, Type 316LN Stainless steel	39.3	270

continuous and have a smooth contour with no undercut permitted.

(b) Welder and welding operator identification shall be marked with a paint pen or maintained by weld maps. Direct stamping of the vessel is not permitted. In lieu of stamping of the material marking on the plates, other methods acceptable to the Authorized Inspector shall be used. Stamping of the ASME Certification Mark shall be on a nameplate attached to a stand-off plate or by other means.

(c) Butt joints shall comply with Section VIII, Division 1, UW-51. Radiographic examinations shall be performed prior to coldstretching. As an alternative to the radiographic examination, ultrasonic examination may be used in accordance with Code Case 2235.

(d) In areas such as nozzle-to-shell attachment locations, abrupt changes in thickness or contour, and other similar structural discontinuities, high local stress and strain concentrations are anticipated during the cold-stretching process. To check for potential crack formation in these areas, after depressurization of the vessel following cold-stretching, all Category A weld joints and all attachment welds shall be examined externally for their entire lengths using the liquid penetrant method in accordance with Section VIII, Division 1, Appendix 8.

(e) Renewed cold-stretching shall be performed if cold-stretched parts of the vessel have been welded after cold-stretching, except for attachment or tack welds less than 0.25 in. (6 mm) in length. Such welds shall be examined as described in (d).

(f) Except when renewed cold-stretching is to be performed, the pressure test required by UG-99 or UG-100 shall be applied after all welding on the pressure retaining parts.

(g) Impact Test Requirements

(1) The cold-stretched base materials listed in Table 1 need not be impact tested when used in vessels constructed in accordance with this Code Case.

(2) The Welding Procedure Qualification shall include impact tests of welds and heat affected zones (HAZ) made in accordance with UG-84(h) and with requirements of UHA-51(a) at MDMT. The specimens

shall be tested from the welded cold-stretched plate. The welded plate shall be cold-stretched by applying tensile stress across the welded joint equal to or greater than 1.5 times the allowable design stress listed in Table 1 of this Code Case. The Welding Procedure Qualification impact tests need not be conducted for MDMT of -55°F (-48°C) and warmer.

(3) The vessel (production) impact tests in accordance with UHA-51(h) are not required for vessels constructed in accordance with this Code Case.

5.2 COLD-STRETCHING OPERATION

(a) The cold-stretching operation shall be performed using the following rules. These rules shall include the steps described in (b) through (f).

(b) Fill the vessel with water with adequate high point venting to ensure complete filling. Allow the vessel to sit with the vents open for at least 15 min to allow any air dissolved in the water to escape. After venting, finish filling the vessel completely and close the vents, top off, and seal the vessel.

(c) Prior to applying the cold-stretching pressure, the circumference of all shell courses shall be measured where the largest increase in cross-section is expected. All measurements shall be made with instruments that have been calibrated to an accuracy of $\pm 0.05\%$. This shall be used to establish a baseline dimensional value. Additional measurements of the vessel while under cold-stretching pressure shall be taken as necessary to calculate the strain rate. The strain rate during the cold-stretching operation shall be calculated over the full circumference. As an alternative to this, the strain rate may also be determined by recording time, pressure, and elongation of the circumference.

(d) The cold-stretching operation shall be carried out as follows:

(1) The pressure shall be increased until the cold-stretching pressure P_c is reached. The cold-stretching pressure shall be maintained until the calculated strain rate has dropped to less than 0.1%/hr.

(2) The minimum holding time under coldstretching pressure shall be not less than one hour, except as described in (e).

(3) The calculated strain rate shall be determined by repeated and/or continuous measurements of the circumference while the vessel is under cold-stretching pressure as described in (c). The required maximum strain rate of 0.1%/hr shall be met during the last half hour.

CAUTION: Pressurized equipment contains stored energy capable of sudden release in the event of a catastrophic failure. The potential hazard is greater as the pressure is increased. It is recommended a "safety zone" be established and maintained around the vessel while cold-stretching pressure is applied. Special care shall be given to minimize the time personnel remain within the "safety zone" while taking the required measurements.

NOTE: The total time under cold-stretching pressure required to achieve the desired strain may be substantial. The amount of time the vessel is subjected to cold-stretching pressure may be reduced somewhat if a 5% higher cold-stretching pressure is applied during the first 30 min to 1 hr to accelerate strain formation.

(e) For pressure vessels having a diameter not more than 79 in. (2 000 mm) the time under pressure may be reduced to 30 min, provided the strain rate of 0.1%/hr is met during the last 15 min.

(f) The strengthening operation replaces the final pressure testing of the vessel. Should later pressure testing be required, the requirements of UG-99 or UG-100 shall be applied.

(g) The cold-stretching process shall be witnessed by the Authorized Inspector (AI).

(h) If the vessel requires welded repair, renewed cold-stretching shall be carried out in accordance with the rules of 5.2.

5.3 COLD-STRETCHING PROCEDURE RECORD

A written record shall be prepared, containing at least the following information:

(a) pressurizing sequence specifying pressure readings and time

(b) results of the circumference measurements before, during and after pressurization, and of the time, pressure, and elongation as an alternative

(c) results of strain rate calculations

(d) notes of any significant changes of shape and size relevant to the functioning of the vessel

(e) information for renewed cold-stretching [according to 5.1(e) and 5.2(h)]

6 STAMPING AND CERTIFICATION

(a) The Certification Mark stamping on the nameplate shall include marking with "CS" under the Certification Mark, indicating the vessel was constructed using cold-stretching methods.

(b) This Case number shall be shown on the Manufacturer's Data Report. Additionally, the Manufacturer shall indicate in the Remarks section of the Manufacturer's Data Report: "This vessel has been constructed using cold-stretch processes."

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Case 2597

Permit Testing a Single Forging to Represent Several Thicknesses

Section VIII, Division 3

Approval Date: May 21, 2008

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the separate test forging permitted by Section VIII, Division 3, KM-211.2(d) be used to represent forgings of several thicknesses in lieu of the requirements in KM-211.2(d)(3)?

Reply: It is the opinion of the Committee that the separate test forging permitted by Section VIII, Division 3, KM-211.2(d) may be used to represent forgings of several

thicknesses in lieu of the requirements in KM-211.2(d)(3), provided the following additional requirements are met:

(a) The separate test forging shall have a weight equal to or greater than the weight of the heaviest forging in the batch to be represented.

(b) The separate test forging shall have a thickness equal to or greater than the thickness of the thickest forging in the batch to be represented.

(c) This Case number shall be shown on the marking and certification of the material and on the Manufacturer's Data Report.

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Case 2598

22Cr-15Ni-Cb-N Austenitic Stainless Steel Seamless Tubing

Section I

Approval Date: January 29, 2008

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-treated 22Cr-15Ni-Cb-N austenitic stainless steel seamless tubing with chemical analysis shown in [Table 1](#), the mechanical properties shown in [Table 2](#), and that otherwise conform to applicable requirements in SA-213/SA-213M be used for steam service in Section I construction?

Reply: It is the opinion of the Committee that the material listed in the Inquiry may be used for steam service in Section I construction, provided that the following requirements are met:

(a) The material shall meet the chemical analysis and minimum tensile requirements described in the Inquiry, and shall otherwise meet the requirements of SA-213/SA-213M as applicable, except as shown in [\(b\)](#) and [\(c\)](#).

(b) The minimum solution-treating temperature for this material shall be 2,120°F (1 160°C).

(c) This material shall have a hardness not exceeding 219 HBW/230 HV (95 HRB).

(d) The rules of PG-19 for TP347H shall apply for this material, except that solution treatment, when required, shall be at the minimum temperature of 2,120°F (1 160°C).

(e) The maximum allowable stress values for the material shall be as given in [Tables 3](#) and [3M](#). The maximum design temperature is 1,382°F (750°C).

(f) Separate welding procedure and performance qualification shall be conducted for the material in accordance with Section IX.

(g) This Case number shall be referenced in the documentation and marking of the material and recorded on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.03–0.10
Manganese, max.	2.00
Phosphorus, max.	0.040
Sulfur, max.	0.030
Silicon, max.	1.00
Nickel	14.5–16.5
Chromium	21.0–23.0
Columbium	0.50–0.80
Nitrogen	0.10–0.20
Boron	0.001–0.005

Table 2
Mechanical Property Requirements

Tensile strength, min., ksi (MPa)	86 (590)
Yield strength, min., ksi (MPa)	34 (235)
Elongation in 2 in. or 50 mm, min., %	35

Table 3
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi	Allowable Stress Values, ksi
-40 to 100	22.7	22.7
200	20.9	22.7 [Note (1)]
300	19.5	22.7 [Note (1)]
400	18.2	22.7 [Note (1)]
500	17.0	22.5 [Note (1)]
600	16.1	21.7 [Note (1)]
650	15.7	21.2 [Note (1)]
700	15.4	20.7 [Note (1)]
750	15.1	20.4 [Note (1)]
800	14.9	20.1 [Note (1)]
850	14.7	19.8 [Note (1)]
900	14.6	19.7 [Note (1)]
950	14.5	19.5 [Note (1)]
1,000	14.4	19.5 [Note (1)]
1,050	14.4	19.4 [Note (1)]
1,100	14.3	16.1 [Note (2)]
1,150	12.1	12.1
1,200	9.0	9.0
1,250	6.9	6.9
1,300	5.4	5.4
1,350	4.4	4.4
1,400	3.7 [Note (3)]	3.7 [Note (3)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these high stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) This allowable stress value for a temperature of 1100°F is obtained from time-dependent properties. Similarly, all the allowable stress values shown at temperatures of 1150°F and above are obtained from time-dependent properties.
- (3) These values are provided for interpolation purposes only.

Table 3M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa	Allowable Stress Values, MPa
-30 to 40	156	156
65	149	156 [Note (1)]
100	143	156 [Note (1)]
125	139	156 [Note (1)]
150	134	156 [Note (1)]
175	130	156 [Note (1)]
200	126	156 [Note (1)]
225	122	156 [Note (1)]
250	119	155 [Note (1)]
275	116	154 [Note (1)]
300	113	152 [Note (1)]
325	110	148 [Note (1)]
350	108	145 [Note (1)]
375	106	143 [Note (1)]
400	104	140 [Note (1)]
425	103	139 [Note (1)]
450	101	137 [Note (1)]
475	101	136 [Note (1)]
500	100	135 [Note (1)]
525	99.5	134 [Note (1)]
550	99.2	134 [Note (1)]
575	99.0	133 [Note (1)]
600	98.9	104 [Note (2)]
625	79.7	79.7
650	61.2	61.2
675	48.0	48.0
700	38.7	38.7
725	32.0	32.0
750	27.1	27.1

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) This allowable stress value for a temperature 600°C is obtained from time-dependent properties. Similarly, all the allowable stress values shown at temperatures of 625°C and above are obtained from time-dependent properties.

Case 2603-2

Use of UNS S32101 Ferritic/Austenitic Stainless Steel Plate, Sheet, Strip, Pipe, and Tube

Section IV

Approval Date: April 15, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S32101 ferritic/austenitic stainless steel in SA-240 plate, sheet, and strip, SA-790 pipe, and SA-789 tube specifications be used in the construction of Section IV hot water heating boilers?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the welded construction of Section IV hot water heating boilers, provided the following requirements are met:

(a) The allowable stress for plate, sheet, strip, seamless pipe and seamless tube in accordance with SA-240, SA-790, and SA-789 shall be as listed in [Tables 1](#) and [1M](#).

(b) The allowable stress for welded pipe and tube in accordance with SA-790 and SA-789 shall be as listed in [Tables 2](#) and [2M](#).

(c) Welding procedure and performance qualification shall be conducted in accordance with Section IX.

(d) For external pressure Fig. HA-5 of Section II, Part D shall be used.

(e) The maximum design temperature shall be 500°F (260°C).

(f) All other requirements of Section IV shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

NOTES:

- (1) This steel may be expected to develop embrittlement after service at moderately elevated temperatures; see Appendix A, A-340 and A-360 Section II, Part D.
- (2) This material may utilize the minimum thickness exceptions of HF-301.1(c) at pressures up to 160 psi (1100 kPa).

Table 1
**Maximum Allowable Stress Values for SA-240 Plate,
Sheet, and Strip, Seamless SA-790 Pipe,
and Seamless SA-789 Tube**

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	20.7
200	19.1
300	17.9
400	17.3
500	17.3

Table 1M
**Maximum Allowable Stress Values for SA-240 Plate,
Sheet, and Strip, Seamless SA-790 Pipe,
and Seamless SA-789 Tube**

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	143
65	137
90	132
150	124
200	120
250	119
300	119 [Note (1)]

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 300°C temperature is provided for interpolation purposes.

Table 2
Maximum Allowable Stress Values
for Welded SA-790 Pipe and Welded SA-789 Tube

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
100	17.6
200	16.2
300	15.2
400	14.7
500	14.7

NOTE: (1) For welded pipe and tube, the allowable stress values have been decreased by a factor of 0.85.

Table 2M
Maximum Allowable Stress Values
for Welded SA-790 Pipe and Welded SA-789 Tube

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
40	122
65	116
90	113
150	105
200	102
250	101
300	101 [Note (2)]

NOTES:

- (1) The maximum use temperature shall be 260°C. Datum for 300°C temperature is provided for interpolation purposes.
- (2) For welded pipe and tube, the allowable stress values have been decreased by a factor of 0.85.

Case 2604

Use of Pneumatic Testing on Individual Cast Aluminum Sections

Section IV

Approval Date: October 2, 2008

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may cast aluminum boiler sections, manufactured by a manufacturer who is in possession of an H Code Symbol Stamp and a valid Certificate of Authorization, be pneumatically tested in lieu of the hydrostatic requirements of HA-406?

Reply: It is the opinion of the Committee that, in lieu of the hydrostatic test provisions as stated in HA-406, the manufacturer of the cast aluminum boiler sections may pneumatically test those sections, provided the following requirements are met:

(a) The maximum allowable working pressure of the casting cannot exceed 60 psi.

(b) The pneumatic test pressure shall be at least $2\frac{1}{2}$ times the maximum allowable working pressure to be stamped on the individual boiler section. In no case shall the pneumatic test pressure exceed $2\frac{1}{2}$ times maximum allowable working pressure by more than 10 psi.

(c) The pressure in the casting shall be gradually increased to no more than one-half of the required test pressure. Thereafter the pressure shall be increased in steps of approximately one-tenth of the required test pressure until the required test pressure has been reached.

Once the required test pressure has been reached, the pneumatic testing shall be considered completed. However, the $1\frac{1}{2}$ times hydrostatic test of the assembled boiler as required by HA-406.1 must still be performed by the assembler.

(d) The Manufacturer is responsible for performing the pneumatic test in a test facility or with test equipment that is capable of containing, including the pressure wave and projectiles, a catastrophic failure of the vessel under the maximum pneumatic test pressure permitted in (b). The Manufacturer shall attest to the adequacy of such a facility or testing equipment by one of the following signed certifications:

(1) for test facilities or test equipment installed in the United States or Canada, certification by a Professional Engineer experienced in design of blast resistant enclosures and registered in either one or more states of the United States or provinces of Canada

(2) for test facilities or test equipment installed outside of the United States and Canada, certification by an Engineer experienced in the design of blast resistant enclosures with qualifications acceptable to the concerned legal jurisdiction

(e) The signed certification shall be identified in the written description of the Quality Control System.

(f) The Manufacturer shall ensure that the test facility or test equipment is designed, constructed, and operated as certified above.

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Case 2605-4

Fatigue Evaluation for Class 2 Parts Constructed With SA-182 F22V; SA-336 F22V; SA-541 22V; SA-542 Type D, Class 4a; and SA-832 Grade 22V at Temperatures Greater Than 371°C (700°F) and Less Than or Equal to 482°C (900°F)

Section VIII, Division 2

Approval Date: July 24, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what requirements may Section VIII, Division 2, Class 2 pressure parts constructed with SA-182 F22V; SA-336 F22V; SA-541 Grade 22V; SA-542 Type D, Class 4a; and SA-832 Grade 22V be evaluated for fatigue for operating temperatures greater than 371°C (700°F) and less than or equal to 482°C (900°F)?

Reply: It is the opinion of the Committee that Section VIII, Division 2, Class 2 pressure parts constructed with SA-182 F22V; SA-336 F22V; SA-541 22V; SA-542 Type D, Class 4a; and SA-832 22V may be evaluated for fatigue for operating temperatures greater than 371°C (700°F) and less than or equal to 482°C (900°F); provided the following requirements are satisfied.

(a) The time, temperature, and load history shall be provided in the User's Design Specification. The load history shall include both design and operating conditions. The design conditions shall be used for analyses defined in (b) and (c). The operating conditions are used for analyses defined in (d) and (e). The maximum permissible temperature for the analyses defined in (d) and (e) is 482°C (900°F).

(b) The design of pressure parts or nonpressure parts, i.e., skirt and skirt attachment, may be in accordance with the design-by-rule requirements of Part 4 or the design-by-analysis requirements of Part 5. In either case, the allowable stress, S , to be used for design shall be in accordance with Table 5A of ASME Section II, Part D. If design-by-analysis is used to qualify the design of a pressure part or nonpressure part, the design-by-analysis shall be based on the elastic stress analysis methods in Part 5.

(c) Restrictions on the design of pressure parts shall be as follows:

(1) The diameter ratio of the shell shall satisfy $D_o/D_i \leq 1.2$.

(2) Standard pressure parts that comply with an ASME product listed in Part 1, Table 1.1, and para. 4.1.11 may be used for closure components or piping connections at the pressure-temperature rating listed in the ASME standard.

(3) The skirt attachment detail shall be in accordance with para. 4.2, Fig. 4.2.4, illustration (e). Figure 4.2.4, illustration (f) may be used if the requirements of (d)(5) are satisfied.

(4) Integral reinforcement shall be used for nozzles and conical transitions.

(5) Flange designed in accordance with Part 4, para. 4.16 may be used for closure components or piping connections, except that the allowable stress, S , shall be in accordance with Table 1A of Section II, Part D.

(6) The rules for external pressure and compressive stress design in Part 4, para. 4.4 may be used if the strain rate computed using eq. (d)(3)(3) based on the membrane stress for the most severe combination of applied loads that results in compressive stress satisfy eq. (1)

$$\dot{\epsilon} \leq \frac{3(10)^{-8}}{\text{hr}} \quad (1)$$

(d) An inelastic analysis including the effect of creep shall be performed for pressure parts based on the following requirements. This analysis is not required for standard pressure parts and bolted flanges specified in (c)(2) and (c)(5).

(1) The inelastic analysis shall be based on the histogram defined in (-a) using one of the following options. Either option may be used for different components in the vessel.

Table 1
MPC Project Omega Creep Data

Material	Strain Rate Parameter, $\dot{\epsilon}_0$ [Note (1)]		Omega Parameter, Ω [Note (1)]	
2.25Cr-1Mo-V	A_0	-25	B_0	-2.52
	A_1	52,210.5	B_1	5,797.6
	A_2	-936.7	B_2	-364.8
	A_3	-1,814	B_3	-228.2
	A_4	-1,171	B_4	294.9

GENERAL NOTE: The coefficients in this table represent minimum material behavior.

NOTE: (1) The units of measure for computing the strain rate parameter, $\dot{\epsilon}_0$, and the Omega parameter, Ω , using the coefficients in this table are ksi and °R.

Table 1M
MPC Project Omega Creep Data

Material	Strain Rate Parameter, $\dot{\epsilon}_0$ [Note (1)]		Omega Parameter, Ω [Note (1)]	
2.25Cr-1Mo-V	A_0	-25.000	B_0	-2.520
	A_1	29 117.173	B_1	3 205.108
	A_2	-202.661	B_2	355.458
	A_3	628.984	B_3	-538.837
	A_4	-650.711	B_4	163.814

GENERAL NOTE: The coefficients in this table represent minimum material behavior.

NOTE: (1) The units of measure for computing the strain rate parameter, $\dot{\epsilon}_0$, and the Omega parameter, Ω , using the coefficients in this table are MPa and °K.

(-a) *Option 1.* An approximate ratcheting analysis may be performed, based on establishing elastic shakedown at all points in the structure. If this option is chosen, a conservative load histogram shall be used based on the most extreme conditions of stress and temperature. A minimum of two complete cycles shall be computed, including a hold time of a minimum of one year, for the purpose of establishing the effects of creep relaxation. During the last computed cycle, a state of linear elasticity must be demonstrated throughout the cycle. If this criterion is not achieved, a full inelastic analysis using the actual time-dependent thermal and mechanical loading histograms shall be performed as per Option 2.

(-b) *Option 2.* If it is elected not to perform a simplified analysis as per Option 1, or if such an analysis is carried out and fails to demonstrate elastic shakedown according to the criterion stated in Option 1, then a full inelastic analysis shall be performed using the actual time-dependent thermal and mechanical loading histograms, including all operating cycles and their asso-

ciated hold times. This analysis shall be continued for all cycles defined in the load histogram including their associated hold times, or until the analysis demonstrates shakedown to a stable state or a steady ratchet deformation. In either case, the strain limits in (6)(-a) shall be satisfied.

Protection against ratcheting may be demonstrated using an elastic analysis in lieu of inelastic analysis. To evaluate protection against ratcheting, the following limit shall be satisfied:

$$P_L + P_b + Q + F \leq (S_h + S_{yc}) \tag{2}$$

(2) Elastic, perfectly plastic stress-strain curves based on the yield strengths consistent with the operating temperature envelope and the following creep rate shall be used in the analysis.

(3) The strain rate to be used in the inelastic analysis (i.e., creep model) shall be determined using eqs. (3) through (14). The coefficients for these equations are provided in Tables 1 and 1M.

$$\dot{\epsilon}_c = \frac{\dot{\epsilon}_{oc}}{1 - D_c} \tag{3}$$

$$\log_{10} \dot{\epsilon}_{oc} = - \left\{ A_0 + \left(\frac{A_1 + A_2 S_l + A_3 S_l^2 + A_4 S_l^3}{T} \right) \right\} \tag{4}$$

$$S_l = \log_{10}(\sigma_e) \tag{5}$$

$$\sigma_e = \frac{1}{\sqrt{2}} \left[(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2 \right]^{0.5} \tag{6}$$

$$D_c = \int_0^t \dot{D}_c dt \leq 1.0 \tag{7}$$

$$\dot{D}_c = \Omega_m \dot{\epsilon}_{oc} \tag{8}$$

$$\Omega_m = \Omega_n^{\delta+1} \tag{9}$$

$$\Omega_n = \max. [(\Omega - n), 3.0] \tag{10}$$

Table 2
Total Accumulated Inelastic Strain

Type of Stress	Equivalent Total Accumulated Inelastic Strain	
	Weld and HAZ	Other Parts
Membrane	0.5%	1.0%
Membrane plus bending	1.25%	2.5%
Local (at any point)	2.5%	5.0%

$$\log_{10} \Omega = B_0 + \left(\frac{B_1 + B_2 S_l + B_3 S_l^2 + B_4 S_l^3}{T} \right) \quad (11)$$

$$n = - \left(\frac{A_2 + 2A_3 S_l + 3A_4 S_l^2}{T} \right) \quad (12)$$

$$\delta = \beta \left(\frac{3p}{\sigma_e} - 1.0 \right) \quad (13)$$

$$p = \frac{\sigma_1 + \sigma_2 + \sigma_3}{3} \quad (14)$$

(4) The inelastic analysis shall be performed for selected locations experiencing the most extreme conditions of stress and temperature to determine the creep life absent fatigue, L_{caf} . Sufficient locations shall be selected to ensure that the most critical conditions have been considered. The creep life absent fatigue is defined as the time in which the inelastic analysis produces an accumulated creep damage such that $0.95 \leq D_c < 1.0$ or 1,000,000 hours, whichever is reached first. A range is given for D_c to account for numerical accuracy in the inelastic analysis. For design purposes and to account for uncertainties in the analysis, a lower value of D_c may be used, at the discretion of the designer, to establish a conservative value for L_{caf} .

(5) The creep damage at all locations shall be such that $D_c < 1.0$. In addition, the weldment and adjacent base material of all weld joints shall be located a minimum distance of 25 mm (1 in.), measured from the weld bevel, from regions where the creep damage, D_c , exceeds 0.50.

(6) Based on the results of the inelastic analysis, the following criteria shall be satisfied:

(-a) The equivalent total accumulated inelastic strain shall not exceed the values in Table 2.

(-b) If the design of the component is based on Part 5, see para. (b), then the protection against local failure shall be determined in accordance with Part 5, para. 5.3.3. This analysis shall not consider the effects of creep.

(e) The permissible number of cycles, N , and the creep life with fatigue, L_{cwf} , at each point in the component shall be determined in accordance with one of the following methods. The permissible number of cycles and the creep life with fatigue shall satisfy the specified design requirements in the User's Design Specification.

(1) If Option 1 is used in (d)(1), the fatigue screening analysis in accordance with Part 5, para. 5.5.2.4 may be used except that the fatigue curves in Figures 1 and 1M and Tables 3 and 3M shall be used in the screening assessment, and the value of S_{as} shall be based on $(10)^4$ cycles. In addition, in Steps 3 and 4 of para. 5.5.2.4, the alternating equivalent stress amplitude based on the primary plus secondary plus peak stress determined from shakedown analysis in (d)(1) may be used instead of $C_T S$. The permissible number of cycles, N , in eq. (15) is determined in Step 3 of para. 5.5.2.4. The creep life with fatigue, L_{cwf} , is determined using eq. (15) or (16), as applicable. The equivalent plastic strain amplitude, $\Delta \varepsilon_{peq}$, in eqs. (15) and (16) may be determined from Table 4 as a function of the alternating equivalent stress amplitude.

$$L_{cwf} = L_{caf} \cdot \left(\frac{\beta_{cf} \cdot \Delta \varepsilon_{peq} \cdot N}{\exp[\beta_{cf} \cdot \Delta \varepsilon_{peq} \cdot N] - 1} \right), \quad \Delta \varepsilon_{peq} > 0 \quad (15)$$

$$L_{cwf} = L_{caf}, \quad \Delta \varepsilon_{peq} = 0 \quad (16)$$

(2) If Option 2 is used in (d)(1), then the fatigue analysis shall be performed in accordance with Part 5, para. 5.5.4, except that the fatigue curves in Figures 1 and 1M and Tables 3 and 3M shall be used to determine the accumulated fatigue damage. The accumulated fatigue damage shall satisfy the requirements of Part 5, para. 5.5.4. The creep life with fatigue, L_{cwf} , is determined using eq. (1)(15) or (1)(16), as applicable. The equivalent plastic strain range for the k^{th} loading condition or cycle in eqs. (17) and (18) is determined directly from the strain-based fatigue analysis results.

$$L_{cwf} = L_{caf} \cdot \left(\frac{\beta_{cf} \cdot \sum_{i=1}^k \Delta \varepsilon_{peq,k}}{\exp \left[\beta_{cf} \cdot \sum_{i=1}^k \Delta \varepsilon_{peq,k} \right] - 1} \right), \quad \Delta \varepsilon_{peq} > 0 \quad (17)$$

$$L_{cwf} = L_{caf}, \quad \Delta\epsilon_{peq} = 0 \quad (18)$$

(f) Nondestructive examination of all welds shall be performed in accordance with Examination Group 1a, see Part 7, Tables 7.1 and 7.2. The supplemental examination for cyclic service in para. 7.4.7 shall be performed.

(g) This Case number shall be marked on the nameplate and shown in the Manufacturer's Data Report.

(h) *Nomenclature*

$A_0...A_4$ = material coefficients for the MPC Project Omega strain-rate-parameter, see [Tables 1](#) and [1M](#)

$B_0...B_4$ = material coefficients for the MPC Project Omega Omega-parameter, see [Tables 1](#) and [1M](#)

β = MPC Project Omega parameter equal to $\frac{1}{3}$

β_{cf} = creep fatigue damage factor equal to 2.0

D_c = creep damage

\dot{D}_c = creep damage rate

$\Delta\epsilon_{peq}$ = equivalent plastic strain amplitude based on the alternating equivalent stress amplitude determined in the fatigue screening analysis

$\Delta\epsilon_{peq,k}$ = equivalent plastic strain amplitude for the k^{th} loading condition or cycle

δ = MPC Project Omega parameter

$\dot{\epsilon}_c$ = creep strain rate

$\dot{\epsilon}_{co}$ = initial creep strain rate at the start of the time period being evaluated based on the stress state and temperature

F = additional stress produced by the stress concentration over and above the nominal stress

L_{caf} = creep life absent fatigue

L_{cwf} = creep life with fatigue

n = MPC Project Omega parameter

N = permissible number of cycles

p = hydrostatic stress

P_b = primary bending equivalent stress

P_L = local primary membrane equivalent stress

Q = secondary equivalent stress resulting from operating loadings

σ_e = effective stress

σ_1 = principal stress in the 1-direction

σ_2 = principal stress in the 2-direction

σ_3 = principal stress in the 3-direction

S_h = allowable stress at the maximum temperature for the cycle under consideration

S_{yc} = yield strength at the minimum temperature for the cycle under consideration

t = time, hr

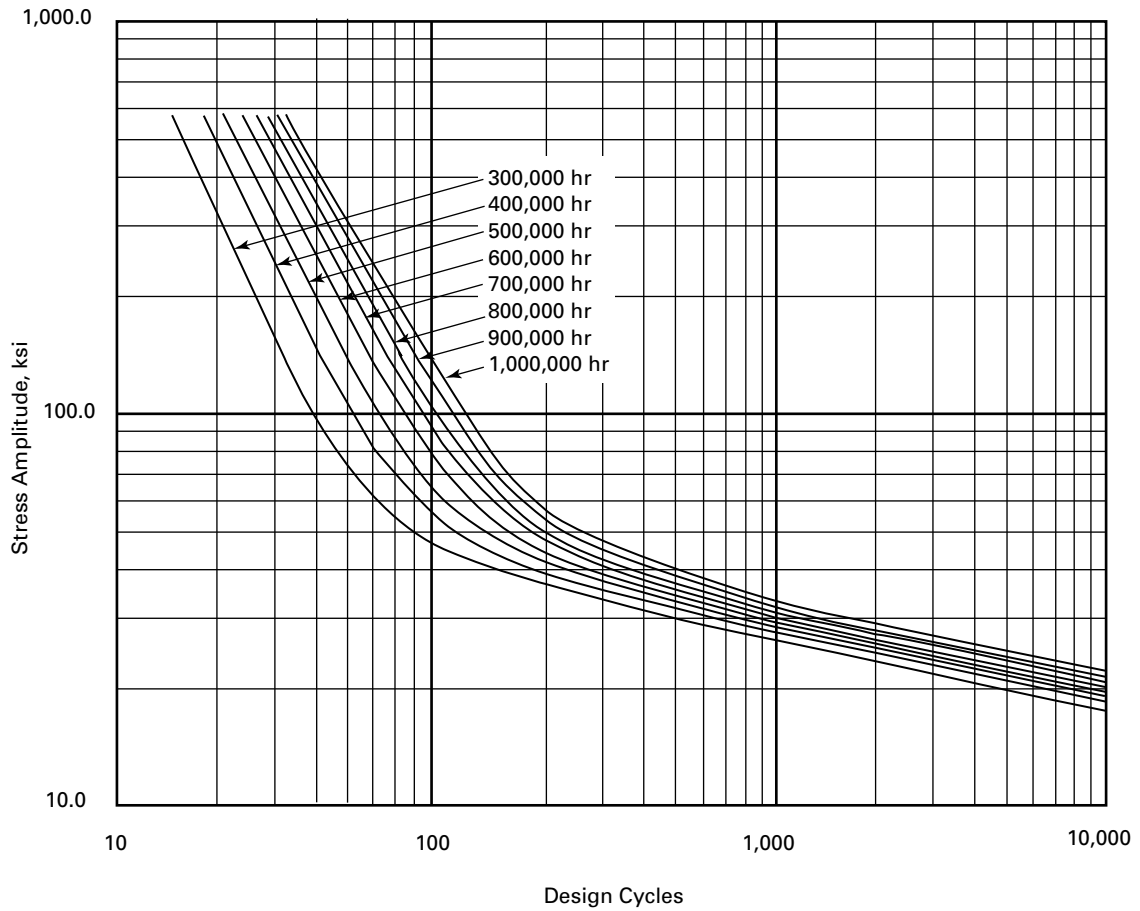
T = temperature

Ω = uniaxial Omega damage parameter

Ω_m = multiaxial Omega damage parameter

Ω_n = adjusted uniaxial Omega damage parameter

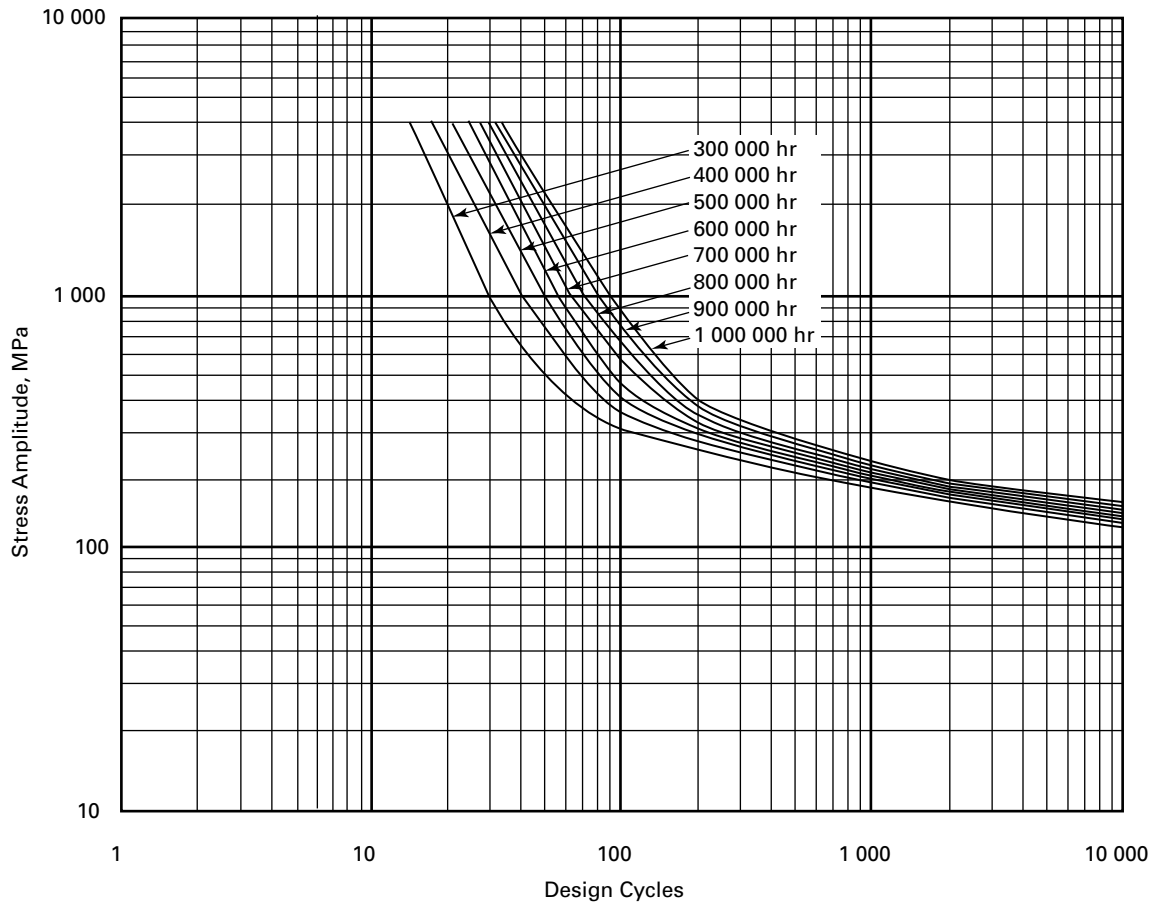
Figure 1
Design Fatigue Curve for 2.25Cr-1Mo-V Steel for Temperatures Not Exceeding 900°F, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue



GENERAL NOTES:

- (a) Interpolation of design cycles as a function of design life is permitted.
- (b) Extrapolation of design cycles as a function of stress amplitude is not permitted.
- (c) The reference temperature and Young's Modulus for these fatigue curves are 900°F and 26,106 ksi, respectively.

Figure 1M
Design Fatigue Curve for 2.25Cr-1Mo-V Steel for Temperatures Not Exceeding 482°C, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue



GENERAL NOTES:

- (a) Interpolation of design cycles as a function of design life is permitted.
- (b) Extrapolation of design cycles as a function of stress amplitude is not permitted.
- (c) The reference temperature and Young's Modulus for these fatigue curves are 482°C and 180 000 MPa, respectively.

Table 3
Design Fatigue Curve for 2.25Cr-1Mo-V Steel for Temperatures Not Exceeding 900°F, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue

Stress Amplitude, ksi	Creep Life Absent Fatigue, hr							
	300,000	400,000	500,000	600,000	700,000	800,000	900,000	1,000,000
577.3	15	18	21	24	26	29	31	32
440.6	17	21	25	28	31	34	37	39
339.2	20	25	29	33	37	40	44	47
263.9	22	28	34	39	43	48	52	56
207.9	26	33	39	45	51	56	61	66
166.2	29	37	45	52	59	65	71	77
135.2	33	42	51	60	68	75	83	89
112.0	37	48	58	68	78	87	95	104
94.6	41	54	66	77	88	99	109	119
81.5	46	61	74	88	100	113	125	136
71.6	52	68	84	99	114	128	142	155
64.1	58	76	94	111	128	145	161	176
58.3	64	85	105	125	144	163	181	199
53.9	72	95	117	139	161	183	204	224
50.3	80	105	131	156	180	205	228	252
47.6	88	117	145	174	201	229	256	282
45.3	98	130	162	193	224	255	285	315
43.4	109	144	180	215	249	284	318	352
41.9	121	160	199	238	277	316	354	392
40.6	133	177	221	265	308	351	394	436
39.4	148	197	245	294	342	390	437	485
38.4	164	218	272	325	379	432	485	538
37.4	181	241	301	360	420	479	538	597
36.6	200	267	333	399	465	531	596	662
35.8	222	295	369	442	515	588	661	734
35.0	245	327	408	489	570	651	732	813
34.3	271	361	451	541	631	721	810	900
33.6	300	400	499	599	698	798	897	996
33.0	332	442	553	663	773	883	993	1,102
32.3	367	489	611	733	855	977	1,098	1,220
31.7	406	541	676	811	946	1,080	1,215	1,350
31.1	449	598	747	897	1,046	1,195	1,344	1,493
30.5	496	661	827	992	1,157	1,322	1,487	1,651
30.0	549	731	914	1,097	1,279	1,462	1,644	1,826
29.4	607	809	1,011	1,213	1,415	1,616	1,818	2,020
28.9	671	894	1,118	1,341	1,564	1,787	2,011	2,234
28.3	742	989	1,236	1,483	1,730	1,976	2,223	2,470
27.8	820	1,093	1,366	1,639	1,912	2,185	2,458	2,731
27.3	906	1,209	1,511	1,813	2,115	2,416	2,718	3,020
26.8	1,002	1,336	1,670	2,004	2,338	2,672	3,006	3,339
26.3	1,108	1,477	1,847	2,216	2,585	2,954	3,323	3,692
25.8	1,225	1,633	2,042	2,450	2,858	3,266	3,674	4,082
25.3	1,354	1,806	2,257	2,709	3,160	3,611	4,063	4,514
24.8	1,497	1,997	2,496	2,995	3,494	3,993	4,492	4,991
24.4	1,656	2,207	2,759	3,311	3,863	4,414	4,966	5,518
23.9	1,830	2,440	3,050	3,661	4,271	4,881	5,491	6,100
23.5	2,024	2,698	3,373	4,047	4,722	5,396	6,070	6,745

Table 3
Design Fatigue Curve for 2.25Cr-1Mo-V Steel for Temperatures Not Exceeding 900°F, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue (Cont'd)

Stress Amplitude, ksi	Creep Life Absent Fatigue, hr							
	300,000	400,000	500,000	600,000	700,000	800,000	900,000	1,000,000
23.1	2,237	2,983	3,729	4,474	5,220	5,966	6,711	7,457
22.6	2,473	3,298	4,122	4,947	5,771	6,596	7,420	8,244
22.2	2,735	3,646	4,558	5,469	6,381	7,292	8,204	9,115
21.8	3,023	4,031	5,039	6,047	7,054	8,062	9,070	10,078
21.4	3,343	4,457	5,571	6,685	7,799	8,913	10,028	11,142
21.0	3,696	4,927	6,159	7,391	8,623	9,855	11,086	12,318
20.6	4,086	5,448	6,809	8,171	9,533	10,895	12,257	13,619
20.2	4,517	6,023	7,528	9,034	10,540	12,045	13,551	15,057
19.9	4,994	6,659	8,323	9,988	11,652	13,317	14,982	16,646
19.5	5,521	7,362	9,202	11,042	12,883	14,723	16,564	18,404
19.1	6,104	8,139	10,174	12,208	14,243	16,278	18,312	20,347
18.8	6,749	8,998	11,248	13,497	15,747	17,996	20,246	22,495
18.4	7,461	9,948	12,435	14,922	17,409	19,896	22,383	24,870
18.1	8,249	10,998	13,748	16,498	19,247	21,997	24,747	27,496
17.8	9,120	12,160	15,200	18,240	21,279	24,319	27,359	30,399
17.4	10,083	13,443	16,804	20,165	23,526	26,887	30,248	33,609
17.1	11,147	14,863	18,579	22,294	26,010	29,726	33,441	37,157
16.8	12,324	16,432	20,540	24,648	28,756	32,864	36,972	41,080
16.5	13,625	18,167	22,709	27,250	31,792	36,334	40,875	45,417
16.2	15,064	20,085	25,106	30,127	35,149	40,170	45,191	50,212
15.9	16,654	22,205	27,757	33,308	38,860	44,411	49,962	55,514
15.6	18,412	24,550	30,687	36,825	42,962	49,100	55,237	61,375
15.3	20,356	27,142	33,927	40,713	47,498	54,284	61,069	67,854

GENERAL NOTES:

- (a) Interpolation of design cycles as a function of design life is permitted.
(b) Extrapolation of design cycles as a function of stress amplitude is not permitted.
(c) The reference temperature and Young's Modulus for these fatigue curves are 900°F and 26,106 ksi, respectively.

Table 3M
Design Fatigue Curve for 2.25Cr-1Mo-V Steel for Temperatures Not Exceeding 482°C, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue

Stress Amplitude, MPa	Creep Life Absent Fatigue, h							
	300 000	400 000	500 000	600 000	700 000	800 000	900 000	1 000 000
3 982	15	18	21	24	26	29	31	32
3 039	17	21	25	28	31	34	37	39
2 339	20	25	29	33	37	40	44	47
1 820	22	28	34	39	43	48	52	56
1 434	26	33	39	45	51	56	61	66
1 147	29	37	45	52	59	65	71	77
932	33	42	51	60	68	75	83	89
772	37	48	58	68	78	87	95	104
652	41	54	66	77	88	99	109	119
562	46	61	74	88	100	113	125	136
494	52	68	84	99	114	128	142	155
442	58	76	94	111	128	145	161	176
402	64	85	105	125	144	163	181	199
371	72	95	117	139	161	183	204	224
347	80	105	131	156	180	205	228	252
328	88	117	145	174	201	229	256	282
312	98	130	162	193	224	255	285	315
300	109	144	180	215	249	284	318	352
289	121	160	199	238	277	316	354	392
280	133	177	221	265	308	351	394	436
272	148	197	245	294	342	390	437	485
265	164	218	272	325	379	432	485	538
258	181	241	301	360	420	479	538	597
252	200	267	333	399	465	531	596	662
247	222	295	369	442	515	588	661	734
242	245	327	408	489	570	651	732	813
237	271	361	451	541	631	721	810	900
232	300	400	499	599	698	798	897	996
227	332	442	553	663	773	883	993	1 102
223	367	489	611	733	855	977	1 098	1 220
219	406	541	676	811	946	1 080	1 215	1 350
215	449	598	747	897	1 046	1 195	1 344	1 493
211	496	661	827	992	1 157	1 322	1 487	1 651
207	549	731	914	1 097	1 279	1 462	1 644	1 826
203	607	809	1 011	1 213	1 415	1 616	1 818	2 020
199	671	894	1 118	1 341	1 564	1 787	2 011	2 234
195	742	989	1 236	1 483	1 730	1 976	2 223	2 470
192	820	1 093	1 366	1 639	1 912	2 185	2 458	2 731
188	906	1 209	1 511	1 813	2 115	2 416	2 718	3 020
185	1 002	1 336	1 670	2 004	2 338	2 672	3 006	3 339
181	1 108	1 477	1 847	2 216	2 585	2 954	3 323	3 692
178	1 225	1 633	2 042	2 450	2 858	3 266	3 674	4 082
175	1 354	1 806	2 257	2 709	3 160	3 611	4 063	4 514
171	1 497	1 997	2 496	2 995	3 494	3 993	4 492	4 991
168	1 656	2 207	2 759	3 311	3 863	4 414	4 966	5 518
165	1 830	2 440	3 050	3 661	4 271	4 881	5 491	6 100
162	2 024	2 698	3 373	4 047	4 722	5 396	6 070	6 745

Table 3M
Design Fatigue Curve for 2.25Cr-1Mo-V Steel for Temperatures Not Exceeding 482°C, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue (Cont'd)

Stress Amplitude, MPa	Creep Life Absent Fatigue, h							
	300 000	400 000	500 000	600 000	700 000	800 000	900 000	1 000 000
159	2237	2983	3729	4474	5220	5966	6711	7457
156	2473	3298	4122	4947	5771	6596	7420	8244
153	2735	3646	4558	5469	6381	7292	8204	9115
150	3023	4031	5039	6047	7054	8062	9070	10078
148	3343	4457	5571	6685	7799	8913	10028	11142
145	3696	4927	6159	7391	8623	9855	11086	12318
142	4086	5448	6809	8171	9533	10895	12257	13619
140	4517	6023	7528	9034	10540	12045	13551	15057
137	4994	6659	8323	9988	11652	13317	14982	16646
135	5521	7362	9202	11042	12883	14723	16564	18404
132	6104	8139	10174	12208	14243	16278	18312	20347
130	6749	8998	11248	13497	15747	17996	20246	22495
127	7461	9948	12435	14922	17409	19896	22383	24870
125	8249	10998	13748	16498	19247	21997	24747	27496
123	9120	12160	15200	18240	21279	24319	27359	30399
120	10083	13443	16804	20165	23526	26887	30248	33609
118	11147	14863	18579	22294	26010	29726	33441	37157
116	12324	16432	20540	24648	28756	32864	36972	41080
114	13625	18167	22709	27250	31792	36334	40875	45417
112	15064	20085	25106	30127	35149	40170	45191	50212
110	16654	22205	27757	33308	38860	44411	49962	55514
108	18412	24550	30687	36825	42962	49100	55237	61375
106	20356	27142	33927	40713	47498	54284	61069	67854

GENERAL NOTES:

- (a) Interpolation of design cycles as a function of design life is permitted.
 (b) Extrapolation of design cycles as a function of stress amplitude is not permitted.
 (c) The reference temperature and Young's Modulus for these fatigue curves are 482°C and 180 000 MPa, respectively.

Table 4
Stress Amplitude Versus Plastic Strain

Alternating Equivalent Stress Amplitude		Equivalent Plastic Strain Amplitude
ksi	MPa	
577.5	3982	0.02000000
440.7	3039	0.01480000
339.2	2339	0.01095200
263.9	1820	0.00810400
207.9	1434	0.00599700
166.3	1147	0.00443800
135.2	932	0.00328400
112.0	772	0.00243000
94.6	652	0.00179800
81.5	562	0.00133100
71.7	494	0.00098500
64.1	442	0.00072900
58.3	402	0.00053900
53.9	371	0.00039900
50.4	347	0.00029500
47.6	328	0.00021900
45.3	312	0.00016200
43.5	300	0.00012000
41.9	289	0.00008860
40.6	280	0.00006550
39.4	272	0.00004850
38.4	265	0.00003590
37.4	258	0.00002660
36.6	252	0.00001960
35.8	247	0.00001450
35.0	242	0.00001080
34.3	237	0.00000796
33.6	232	0.00000589
33.0	227	0.00000436
32.3	223	0.00000323
31.7	219	0.00000239
31.1	215	0.00000177
30.5	211	0.00000131
30.0	207	0.00000097

GENERAL NOTES:

- (a) The plastic strain below 207 MPa (30 ksi) shall be taken as 0.0.
- (b) Interpolation of data values is permitted.
- (c) Extrapolation of data values is not permitted.

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Case 2606

Use of SA-350, Grade LF2, Class 1 Steel Forgings

Section I

Approval Date: January 26, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May steel forgings conforming to SA-350, Grade LF2, Class 1 be used in Section I construction?

Reply: It is the opinion of the Committee that steel forgings conforming to SA-350, Grade LF2, Class 1 may be used in Section I construction, provided the following requirements are met:

(a) The maximum allowable stress values for the material shall be those given in [Tables 1](#) and [1M](#).

(b) The maximum design temperature shall be 850°F (454°C).

(c) Welding procedure and performance qualifications shall be performed in accordance with Section IX.

(d) The final postweld heat treatment shall be that shown in Table PW-39 for P-No.1 material.

(e) For external pressure applications, use Chart No. CS-2 of Section II, Part D.

(f) This Case number shall be identified in the Manufacturer's Data Report.

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress, ksi
-20 to 400	20.0
500	19.6
600	18.4
650	17.8
700	17.2
750	14.8 [Note (1)]
800 [Note (2)]	12.0 [Note (1)]
850 [Note (2)]	9.3 [Note (1)]

NOTES:

- (1) The stress values at 750°F and higher are based on time-dependent properties.
- (2) Upon prolonged exposure to temperatures at or above 800°F, the carbide phase of carbon steel may be converted to graphite.

Table 1M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress, MPa
-30 to 200	138
250	136
300	129
325	125
350	122
375	117
400	101 [Note (1)]
425 [Note (2)]	83.9 [Note (1)]
450 [Note (2)]	67.0 [Note (1)]
475 [Note (2)] and [Note (3)]	51.1 [Note (1)]

NOTES:

- (1) The stress values at 400°C and higher are based on time-dependent properties.
- (2) Upon prolonged exposure to temperatures at or above 425°C, the carbide phase of carbon steel may be converted to graphite.
- (3) The stress value at 475°C is provided for interpolation only. The maximum design temperature is stated in [\(b\)](#) of the Reply.

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Case 2607

Use of SA-420, Grade WPL6 and Welded Steel Fittings

Section I

Approval Date: January 26, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May seamless and welded steel fittings conforming to SA-420, Grade WPL6 be used in Section I construction?

Reply: It is the opinion of the Committee that seamless and welded steel fittings conforming to SA-420, Grade WPL6 may be used in Section I construction, provided the following requirements are met:

(a) The maximum allowable stress values for the material shall be those given in [Tables 1](#) and [1M](#).

(b) The maximum design temperature shall be 850°F (454°C).

(c) Welding procedure and performance qualifications shall be performed in accordance with Section IX.

(d) The final postweld heat treatment shall be that shown in Table PW-39 for P-No. 1 material.

(e) For external pressure applications, use Chart No. CS-2 of Section II, Part D.

(f) This Case number shall be identified on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Max. Allowable Stress, Seamless Pipe Fittings, ksi	Max. Allowable Stress, Welded Pipe Fittings, ksi
-20 to 650	17.1	14.6
700	15.6 [Note (1)]	13.3 [Note (1)]
750	13.0 [Note (1)]	11.1 [Note (1)]
800 [Note (2)]	10.8 [Note (1)]	9.2 [Note (1)]
850 [Note (2)]	8.7 [Note (1)]	7.4 [Note (1)]

NOTES:

(1) The stress values at 700°F and higher are based on time-dependent properties.

(2) Upon prolonged exposure to temperatures at or above 800°F, the carbide phase of carbon steel may be converted to graphite.

Table 1M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Max. Allowable Stress, Seamless Pipe Fittings, MPa	Max. Allowable Stress, Welded Pipe Fittings, MPa
-30 to 325	118	101
350	117	99.7
375	105 [[Note (1)]]	89.7 [[Note (1)]]
400	88.9 [[Note (1)]]	75.9 [[Note (1)]]
425 [Note (2)]	75.3 [[Note (1)]]	64.1 [[Note (1)]]
450 [Note (2)]	62.7 [[Note (1)]]	53.3 [[Note (1)]]
475 [Note (2)] and [Note (3)]	45.5 [[Note (1)]]	38.6 [[Note (1)]]

NOTES:

(1) The stress values at 375°C and higher are based on time-dependent properties.

(2) Upon prolonged exposure to temperatures at or above 425°C, the carbide phase of carbon steel may be converted to graphite.

(3) The stress value at 475°C is provided for interpolation only. The maximum design temperature is stated in [\(b\)](#) of the Reply.

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Case 2608

Testing of Vessels Containing an Internal Piston

Section VIII, Division 1

Approval Date: January 26, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a single chamber pressure vessel that includes an internal piston be tested under the rules of Section VIII, Division 1, with one side to be hydrostatically tested per UG-99, and the other to be pneumatically tested per UG-100?

Reply: It is the opinion of the Committee that a single chamber pressure vessel that includes an internal piston that separates the chamber into two sections may be tested using subsequent hydrostatic and pneumatic tests in lieu of the requirements of UG-99 or UG-100, provided the following requirements are met:

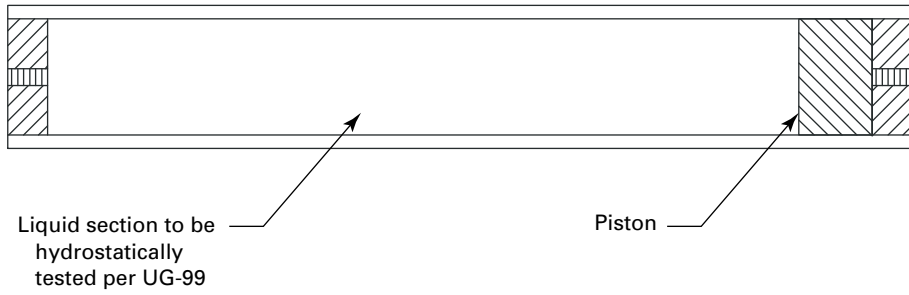
(a) The liquid section shall be hydrostatically tested per UG-99. During this test, the internal piston shall be positioned against the vessel head on the gas side (see [Figure 1](#)).

(b) The gas section shall be pneumatically tested per UG-100. During this test, the internal piston shall be positioned such that, as a minimum, the vessel area previously covered by the piston during the hydrostatic test is now exposed to the pneumatic test (see [Figure 2](#)).

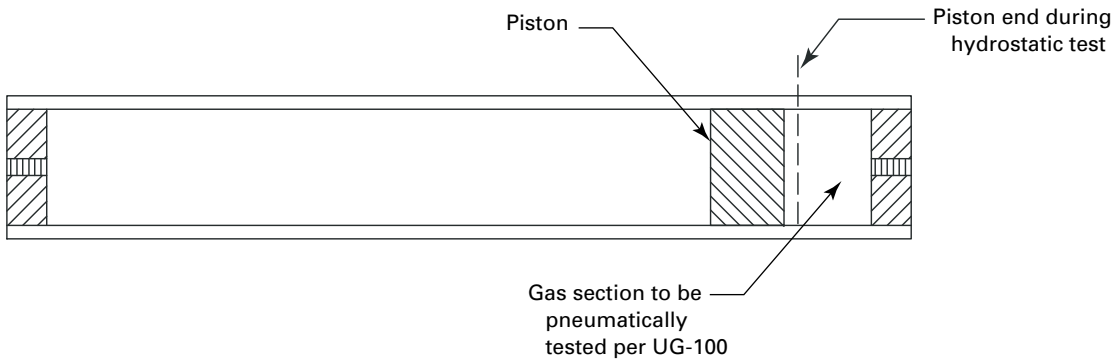
(c) The vessel section to be pneumatically tested shall be nondestructively examined in accordance with the rules of UW-50.

(d) This Case number shall be shown on the Manufacturer's Data Report.

**Figure 1
Hydrostatic Test**



**Figure 2
Pneumatic Test**



Case 2609

Use of Chromium-Silicon Alloy Steel Wire ASTM A401/A401M-03 UNS G92540

Section VIII, Division 3

Approval Date: January 26, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ASTM A401/A401M-03, UNS G92540 be used for manufacture of special closure parts designed in accordance with Article KD-6 of Section VIII, Division 3?

Reply: It is the opinion of the Committee that the material, UNS G92540 and otherwise conforming to ASTM A401/A401M-03, described in the Inquiry may be used in the construction of closure parts conforming to the rules of Article KD-6 of Section VIII, Division 3, provided the following additional requirements are met:

(a) The maximum design temperature shall be 100°F (38°C).

(b) The material shall be manufactured with the minimum and maximum tensile strength values listed in [Table 1](#) and [Table 1M](#).

(c) Tensile strength values used in design shall be the minimum tensile strength values of [Table 1](#) and [Table 1M](#). Tensile strength values for intermediate diameters may be

linearly interpolated. The tensile strength used for design shall be determined using (d) for material that is not of a round cross section.

(d) The mechanical testing of the material shall be performed once it is in the final cross sectional shape and heat treated in accordance with the specification prior to coiling into a helical spring. The material shall be certified to the mechanical properties for a diameter of wire that has a cross sectional area equivalent to that of the cross sectional area of the wire in the final shape.

(e) Welding is not permitted.

(f) The material shall not be used for fabrication of other pressure retaining components, such as bolting, wire wound vessels, or wire wound frames.

(g) Certification of the material in accordance with ASTM A401/A401M-03, para. 13.1 to the requirements of this Case and the balance of ASTM A401/A401M-03 shall be mandatory, including comparison of results of physical testing performed to specification requirements.

(h) This Case number shall be shown on the material certification, marking on the material, and on the Manufacturer's Data Report.

Table 1
Tensile Strength Values, S_u

Diameter, in.	S_u min., ksi	S_u max., ksi
0.032	290	315
0.041	280	305
0.054	270	295
0.062	265	290
0.08	255	275
0.105	245	265
0.135	235	255
0.162	225	245
0.192	220	240
0.244	210	230
0.283	205	225
0.312	203	223
0.375	200	220
0.438	195	215
0.5	190	210

Table 1M
Tensile Strength Values, S_u

Diameter, mm	S_u min., MPa	S_u max., MPa
0.8	1980	2140
0.9	1960	2120
1	1940	2100
1.1	1920	2080
1.2	1900	2060
1.4	1860	2020
1.6	1820	1980
1.8	1800	1960
2	1780	1930
2.2	1750	1900
2.5	1720	1860
2.8	1680	1830
3	1660	1800
3.5	1620	1760
4	1580	1720
4.5	1560	1680
5	1520	1640
5.5	1480	1620
6	1460	1600
6.5	1440	1580
7	1420	1560
8	1400	1540
9	1380	1520
10	1360	1500
11	1340	1480
12	1320	1460

Case 2610

SA-453, Grade 660, Class C, High Temperature Bolting Materials With Expansion Coefficients Comparable to Austenitic Steels

Section VIII, Division 1; Section VIII, Division 2

Approval Date: January 26, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May bolts manufactured of material in accordance with SA-453, Grade 660, Class C be used in Section VIII, Division 1 or Section VIII, Division 2 (2007 edition and later) construction?

Reply: It is the opinion of the Committee that bolts manufactured of material in accordance with SA-453, Grade 660, Class C may be used in the Section VIII, Division

1 or Section VIII, Division 2 construction, provided the following additional requirements are met:

(a) The maximum allowable stress values of the material shall be those given in [Table 1](#) and [Table 1M](#).

(b) The maximum temperature for Section VIII, Division 1 shall be 1000°F (538°C).

(c) The maximum temperature for Section VIII, Division 2 shall be 800°F (427°C).

(d) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Div. 1 Allowable Stress Value, or Div. 2 Design Stress Intensity Value for Flanges Designed to Part 4; Max., ksi	Div. 2 Design Stress Intensity Value; for Flanges Designed to Part 5; Max., ksi
100	21.3	28.3
200	21.3	27.8
300	21.3	27.3
400	21.3	26.9
500	21.3	26.4
600	21.3	26.0
650	21.3	25.7
700	21.3	25.5
750	21.3	25.2
800	21.3	25.0
850	21.3	...
900	21.3	...
950	21.3	...
1000	21.3	...

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Div. 1 Allowable Stress Value, or Div. 2 Design Stress Intensity Value for Flanges Designed to Part 4; Max., MPa	Div. 2 Design Stress Intensity Value; for Flanges Designed to Part 5; Max., MPa
40	147	195
100	147	191
150	147	188
200	147	186
250	147	183
300	147	180
325	147	179
350	147	177
375	147	176
400	147	174
425	147	172
450	147	170 [Note (1)]
500	147	...
525	147	...
550	147 [Note (1)]	...

NOTE: (1) Value for interpolation only.

Case 2611

Use of SA/EN 10028-3, Grade P355N,¹ Fine Grain Normalized Steel Plates

Section VIII, Division 2

Approval Date: January 26, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may steel plate, manufactured in accordance with SA/EN 10028-3, Grade P355N, be used in Division 2, 2004 Edition (including 2006 Addenda) construction?

Reply: It is the opinion of the Committee that steel plate manufactured in accordance with SA/EN 10028-3, Grade P355N, may be used in Section VIII, Division 2, 2004 Edition (including 2006 Addenda) construction, provided the following additional requirements are met:

(a) The thickness of the plates shall not exceed $\frac{5}{8}$ in. (16 mm).

(b) The design temperature shall not exceed 120°F (49°C).

(c) The design stress intensity, S_m , shall be 23.7 ksi (163 MPa).

(d) For external pressure design, the requirements of Fig. CS-3 of Section II, Part D, shall apply.

(e) The provisions for impact test exemption in AM-218 shall not apply.

(f) For the purpose of postweld heat treatment, the material shall be considered as P-No. 1, Gr. 2.

(g) Separate welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(h) Welding by electroslag or electrogas process is not permitted.

(i) The permitted types of welds and the required examination shall be in accordance with Table AF-241.1, Column 1.

(j) This Case number shall be shown on the Manufacturer's Data Report.

¹ See Section II, Part A, Nonmandatory Appendix A for ordering information for Specification EN10028-3 and its references.

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Case 2613

Phenolic Lining Material in HLW-200 Application

Section IV

Approval Date: January 30, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may baked phenolic coatings be used to line water heaters and storage tanks construction in accordance with Part HLW, Section IV?

Reply: It is the opinion of the Committee that baked phenolic linings may be used to satisfy the requirements of HLW-200, provided the following conditions are met:

(a) Baked phenolic linings shall be of an analysis intended for use in potable hot water service, and the minimum thickness shall be 0.004 in. (0.1 mm).

(b) If multiple coats are used, each intermediate coat shall be cured at a minimum metal temperature of 250°F (120°C) for a length of time suitable to sufficiently harden the coat for further processing.

(c) For final coated surfaces the lining shall be cured at a metal temperature of 400°F to 425°F (205°C to 218°C) for 60 to 90 minutes. The manufacturer shall inspect the lining to verify proper cure and minimum thickness and to verify that it is free of discontinuities. Documentation of the basis of the temperature/time used and records of the inspection shall be available to the Inspector.

(d) The absorption rate of the cured lining shall be less than 2% by the method specified in SD-570 shown in Appendix I.

(e) Surfaces to be phenolic-lined must be cleaned to remove all scale, oxidation, oil, etc., prior to application of the lining.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2616-1

2014-T6 Aluminum Hand Forgings for Nonwelded Construction

Section VIII, Division 1

Approval Date: September 23, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 2014-T6 (UNS A92014) aluminum hand forgings produced in compliance with ASTM B247-02a be used in Section VIII, Division 1 nonwelded construction?

Reply: It is the opinion of the Committee that 2014-T6 (UNS A92014) aluminum hand forgings produced in compliance with ASTM B247-02a may be used in

Section VIII, Division 1 nonwelded construction, provided the following requirements are met:

(a) The forging thickness shall be thicker than 3.0 in. (75 mm) and no thicker than 4.0 in. (100 mm).

(b) The maximum allowable stress values shall be those given in [Table 1](#) or [1M](#).

(c) The maximum design temperature shall be 250°F (121°C).

(d) This Case number shall be recorded on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi [Note (1)]
100	17.4
150	17.4
200	17.4
250	14.4

NOTE:

- (1) The allowable stress values were determined by comparing the mechanical properties for SB-247 for 2014-T6 die forgings (2.02 in. to 4.0 in. thick) to ASTM B247-02a for 2014-T6 hand forgings (3.0 in. to 4.0 in. thick):
 - (a) Specified Minimum Yield Strength is 90% of ultimate tensile strength (UTS) for both die and hand forging product forms, indicating allowable stresses in Section II-D for SB-247 die forgings are UTS based.
 - (b) UTS for 2014-T6 hand forgings in Table 5 of ASTM B247-02a is 97% of the UTS for 2014-T6 die forgings in Table 2 of SB-247.
 - (c) The allowable stress values for SB-247 2014-T6 die forgings in Section II, Part D, Table 1B were multiplied by a factor of 0.97.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa [Note (1)], [Note (2)]
40	120
65	120
100	117
125	95.7

NOTES:

- (1) The allowable stress values were determined by comparing the mechanical properties for SB-247 for 2014-T6 die forgings (2.02 in. to 4.0 in. thick) to ASTM B247-02a for 2014-T6 hand forgings (3.0 in. to 4.0 in. thick):
 - (a) Specified Minimum Yield Strength is 90% of ultimate tensile strength (UTS) for both die and hand forging product forms, indicating allowable stresses in Section II-D for SB-247 die forgings are UTS based.
 - (b) UTS for 2014-T6 hand forgings in Table 5 of ASTM B247-02a is 97% of the UTS for 2014-T6 die forgings in Table 2 of SB-247.
 - (c) The allowable stress values for SB-247 2014-T6 die forgings in Section II, Part D, Table 1B were multiplied by a factor of 0.97.
- (2) The allowable stress value given for 125°C is not intended to indicate acceptability for use at temperatures warmer than 121°C, but are provided for interpolating allowable stress values for temperatures warmer than 100°C and no warmer than 121°C.

Case 2617

18Cr-15Ni-4Mo-3Cu-N, UNS S31727, Austenitic Stainless Steel

Section VIII, Division 1

Approval Date: May 9, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 18Cr-15Ni-4Mo-3Cu-N, UNS S31727, austenitic stainless steel sheet, strip, plate, pipe, tube, and bar, meeting the chemical composition and mechanical property requirements shown in Tables 1 and 2, and otherwise conforming to one of the specifications given in Table 3, be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section VIII, Division 1 construction, provided the following additional requirements are met:

(a) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UHA for austenitic stainless steels.

(b) For external pressure, use Fig. HA-4 of Section II, Part D.

(c) The maximum allowable stress values for the material shall be those given in Tables 4 and 4M. For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

(d) Maximum design temperature of the material shall be 800°F (427°C).

(e) Separate welding procedure and performance qualifications shall be conducted for the material in accordance with Section IX. When welding this material to itself, GTAW welding process welded with ERNiCrMo-4 (UNS N10276) or similar corrosion resistant weld filler metals shall be used.

(f) Heat treatment after forming or fabrication is neither required nor prohibited. However, if heat treatment is applied, the solution annealing treatment shall be as noted in (g).

(g) The material shall be furnished in the solution annealed condition at a temperature range from 1975°F to 2155°F (1080°C to 1180°C) followed by rapid cooling in air or water.

(h) This Case number shall be shown on the documentation and marking of the material and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon, max.	0.030
Manganese, max.	1.00
Phosphorus, max.	0.030
Sulfur, max.	0.030
Silicon, max.	1.00
Nickel	14.50–16.50
Chromium	17.50–19.00
Molybdenum	3.80–4.50
Copper	2.80–4.00
Nitrogen	0.15–0.21

Table 2
Mechanical Property Requirements

Tensile strength, min., ksi (MPa)	80 (550)
Yield strength, min., ksi (MPa)	36 (245)
Elongation in 2 in. or 50 mm, min., %	35
Hardness HRB (HB), max.	96 (217)

Table 3
Product Specifications

Bars and shapes	SA-479
Flanges, fittings, and valves	SA-182
Piping fittings	SA-403
Seamless and welded pipes	SA-312
Sheet, strip, and plate	SA-240
Welded pipes	SA-358, SA-409, SA-813, SA-814
Welded tubes	SA-249

Table 4
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi	
100	22.9	22.9
200	20.8	22.8 [Note (1)]
300	18.9	21.4 [Note (1)]
400	17.7	20.5 [Note (1)]
500	17.0	19.9 [Note (1)]
600	16.6	19.6 [Note (1)]
650	16.3	19.5 [Note (1)]
700	16.1	19.5 [Note (1)]
750	15.7	19.4 [Note (1)]
800	15.4	19.3 [Note (1)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 4M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, Max., MPa	
40	158	158
65	157	157
100	140	155 [Note (1)]
125	134	151 [Note (1)]
150	128	147 [Note (1)]
200	121	141 [Note (1)]
250	116	138 [Note (1)]
300	114	135 [Note (1)]
325	112	135 [Note (1)]
350	111	134 [Note (1)]
375	109	134 [Note (1)]
400	107	132 [Note (1)]
425	105	132 [Note (1)]
450	103	131 [Note (1)], [Note (2)]

GENERAL NOTE: The revised criterion of 3.5 on tensile strength was used in establishing these values.

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purpose only. The maximum use temperature is 800°F (427°C).

Case 2618

Use of SB-148 C95500, As-Cast Temper, in the Manufacture of Heating Boilers, Part HF and Potable-Water Heaters, Part HLW

Section IV

Approval Date: July 5, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SB-148 C95500, as-cast temper, be used in the construction of Section IV heating boilers, Part HF and potable-water heaters, Part HLW?

Reply: It is the opinion of the Committee that SB-148 C95500 in the as-cast temper may be used in the construction of Section IV heating boilers, Part HF and potable-water heaters, Part HLW, provided the following requirements are met:

(a) The minimum allowable thickness shall be as shown in HF-301.2.

(b) The maximum allowable stresses are as shown in Tables 1 and 1M.

(c) The material shall not be brazed nor welded.

(d) The material shall not be heat treated.

(e) The maximum use temperature for hot water heating boilers and hot water supply boilers shall be as stated in HG-101.

(f) The maximum use temperature for water heaters shall be as stated in HLW-101.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi
100	18.0
150	18.0
200	18.0
250	18.0
300	18.0
350	18.0 [Note (1)]

GENERAL NOTE: The (maximum allowable) stress value includes a casting quality factor of 0.80. Increased casting quality factors as a result of material examination beyond the requirement of the material specification shall not be permitted.

NOTE: (1) Values for 350°F and 175°C are provided for interpolation purposes only.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Max. Allowable Stress Values, MPa
40	124
65	124
100	124
125	124
150	124
175	124 [Note (1)]

GENERAL NOTE: The (maximum allowable) stress value includes a casting quality factor of 0.80. Increased casting quality factors as a result of material examination beyond the requirement of the material specification shall not be permitted.

NOTE: (1) Values for 350°F and 175°C are provided for interpolation purposes only.

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Case 2619

Use of ASTM A414/A414M-07

Section VIII, Division 1

Approval Date: June 24, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May hot-rolled carbon steel sheet conforming to ASTM A414/A414M-07 be used in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that hot-rolled carbon steel sheet conforming to ASTM A414/A414M-07 may be used in Section VIII, Division 1 construction, provided the following requirements are met:

(a) The allowable stress shall be per SA-414/SA-414M in Section II, Part D, Table 1A.

(b) All other requirements for Section VIII, Division 1 for SA-414/SA-414M shall be met.

(c) This Case number shall appear on the Manufacturer's Data Report Form.

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Case 2620-3

Use of UNS S32101 Ferritic/Austenitic Stainless Steel Plate, Sheet, Strip, Pipe, and Tube in the Manufacture of Part HLW Water Heaters and Storage Tanks

Section IV

Approval Date: October 6, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S32101 ferritic/austenitic stainless steel in SA-240 plate, SA-790 pipe, and SA-789 tube specifications be used in the construction of unlined Section IV, Part HLW water heaters and storage tanks?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the welded construction of Section IV, Part HLW water heaters and storage tanks, provided the following requirements are met:

(a) The allowable stress values for plate, sheet, and strip, seamless pipe, and seamless tube in accordance with SA-240, SA-789, and SA-790 shall be as listed in [Tables 1](#) and [1M](#).

(b) Welding procedure and performance qualification shall be conducted in accordance with Section IX.

(c) As an alternative to calculation using the listed stress values, the allowable working pressure of the water or storage tank may be established in accordance with the proof test provision of HLW-500.

(d) The maximum design temperature shall be 500°F (260°C).

(e) All other requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for SA-240 Plate, Sheet, and Strip, Seamless SA-790 Pipe, and Seamless SA-789 Tube

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	<i>t</i> ≤ 0.187 in.	<i>t</i> > 0.187 in.
100	25.3	23.5
200	25.3	23.5
300	24.1	22.4
400	23.2	21.6
500	23.2	21.6

GENERAL NOTES:

- (a) This steel may be expected to develop embrittlement after service at moderately elevated temperatures; see Nonmandatory Appendix A, A-207 and A-208 of Section II, Part D.
- (b) This material may utilize the minimum thickness exceptions of HF-301.1(c).
- (c) Values for welded pipe to SA-790 and tube to SA-789 are found by multiplying the above values by 0.85.

Table 1M
Maximum Allowable Stress Values for SA-240 Plate, Sheet, and Strip, Seamless SA-790 Pipe, and Seamless SA-789 Tube

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	<i>t</i> ≤ 5 mm	<i>t</i> > 5 mm
40	175	163
65	175	163
100	175	163
150	167	155
175	161	152
200	160	150
225	160	149
250	160	149
275	160 [Note (1)]	149 [Note (1)]

GENERAL NOTES:

- (a) This steel may be expected to develop embrittlement after service at moderately elevated temperatures; see Nonmandatory Appendix A, A-207 and A-208 of Section II, Part D.
- (b) This material may utilize the minimum thickness exceptions of HF-301.1(c).
- (c) Values for welded pipe to SA-790 and tube to SA-789 are found by multiplying the above values by 0.85.

NOTE: (1) The maximum use temperature shall be 260°C. The value at 275°C temperature is provided for interpolation purposes.

Case 2624-1

Intermodal Transport Tanks (UN T50 Portable Tanks) for Class 2

Section VIII, Division 2

Approval Date: December 2, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UN T50 portable tanks mounted in ISO frames, fitted with pressure relief devices in accordance with DOT Regulation 49 CFR, Part 178.276 set in the range 100% – 110% of the design pressure and used for intermodal transport (i.e., by motor vehicle, rail freight, and/or cargo vessel) be constructed and stamped under the rules of para. 1.2.1.3(b) of Section VIII, Division 2 for Class 2?

Reply: It is the opinion of the Committee that UN T50 portable tanks mounted in ISO frames, fitted with pressure relief devices in accordance with DOT Regulation 49 CFR, Part 178.276 set in the range 100% – 110% of the design pressure and used for intermodal transport (i.e., by motor vehicle, rail freight, and/or cargo vessel) may be constructed and stamped under the rules of para. 1.2.1.3(b) of Section VIII, Division 2, provided the requirements of paras. 1.2.1.3(b) and 1.2.1.3(b)(1) and (2), and the following additional requirements are met for all applicable modes of transport:

(a) The maximum design temperature shall not exceed 66°C (150°F).

(b) In Table 4.1.1, Design Loads, and Table 5.2, Load Descriptions, add the following condition:

Design Load Parameter	Description
V	Motor vehicle, rail-, or water-borne transport loads

(c) In Table 4.1.2, Design Load Combinations, and Table 5.3, Load Case Combinations and Allowable Membrane Stresses for an Elastic Analysis, add the following condition:

Design Load Combination [Note (1)]	General Primary Membrane Allowable Stress [Note (2)]
$P + 0.9P_s + 0.9D + 0.9V$ [Note (3)][Note (4)]	S [Note (5)]

NOTES:

- (1) (For Note 1, see Table 4.1.2. Notes 2 through 5 below replace Notes 2 through 4 in Table 4.1.2.)
- (2) The materials permitted and the respective maximum allowable stress values shall be those given in Tables 1 and 1M.

NOTES: (Cont'd)

- (3) The design pressure shall be taken to act simultaneously with the loads from motor vehicle, rail, or water-borne transport. However, loads from various modes of transport need not be assumed to act simultaneously.
- (4) When the rules of this Division are used in the design of pressure vessels transported by motor vehicle, rail, and/or water, loads from abnormal pressure vessel orientation and dynamic loads produced by shock, vibration, or impact loading, for evaluation under parameter V, shall be specified by the regulatory (jurisdictional) authority or authorities.
- (5) Based on corroded thickness at design metal temperature of 66°C (150°F) and colder.

(d) In Table 4.1.1, the operating load conditions that are the basis of fatigue evaluation shall include loads and load spectra caused by abnormal pressure vessel orientation, impact, shock, vibration, fluid sloshing, and temperature and pressure fluctuations.

(e) The loads referred to in paras. (a), (b), and (c) shall be defined in the User's Design Specification.

(f) The minimum thickness of shell, heads, nozzles, closures, or sumps shall not be less than the required thicknesses in accordance with the rules of Part 4 of Section VIII, Division 2.

(g) A means for retaining records of original construction, inspection, repair, accidents, and unusual loadings shall be established by the regulatory (jurisdictional) authority and implemented by the user. Any additional record retention requirements shall be specified in the User's Design Specification.

(h) All other applicable requirements of Section VIII, Division 2 shall be met.

(i) This Case number shall be shown in the Manufacturer's Data Report and marked on the nameplate.

Table 1
Materials Permitted and Maximum Allowable Stresses,
ksi

Material Specification	Temperature, -20°F to 150°F
SA-105	22.6
SA-106 Gr. B	20.0
SA-350 LF2	22.6
SA-516 Gr. 70	23.3
SA-612 [Note (1)]	27.7
SA-612 [Note (2)]	27.0
SA-299/SA-299M	25.0
SA/EN 10028-3, Grade P460NL1 [Note (3)]	30.5

NOTES:

- (1) $t \leq 0.5$ in.
- (2) 0.5 in. $< t \leq 1$ in.
- (3) Per Code Case 2594.

Table 1M
Materials Permitted and Maximum Allowable Stresses,
MPa

Material Specification	Temperature, -29°C to 65°C
SA-105	156
SA-106 Gr. B	138
SA-350 LF2	156
SA-516 Gr. 70	161
SA-612 [Note (1)]	190
SA-612 [Note (2)]	186
SA-299/SA-299M	172
SA/EN 10028-3, Grade P460NL1 [Note (3)]	210

NOTES:

- (1) $t \leq 13$ mm
- (2) 13 mm $< t \leq 25$ mm
- (3) Per Code Case 2594.

Case 2627

Use of Aluminum Alloy EN AW-6060 T1 Extruded (Integrally) Finned Tube in the Manufacture of Hot Water Heating Boilers

Section IV

Approval Date: September 30, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May aluminum alloy EN AW-6060 T1 extruded finned and coiled tube meeting the chemical composition listed in [Table 1](#), the mechanical properties listed in [Table 2](#), and heat treatment “temper designation T1” according to EN 515 August 1993, be used in construction for hot water heating boilers under the rules of Section IV?

Reply: It is the opinion of the Committee that aluminum alloy EN AW-6060 T1 extruded finned and coiled tube meeting the requirements described in the Inquiry may be used in Section IV, construction of hot water heating boilers, under the following conditions:

(a) Maximum allowable working pressure shall not exceed 50 psi (350 kPa).

(b) The maximum water temperature shall be 220°F (105°C).

(c) The maximum allowable stress values shall be as shown in [Table 3](#) and [Table 3M](#).

(d) The material shall otherwise conform to the specifications listed in [Table 4](#).

(e) The minimum allowable thickness shall be 0.079 in. (2 mm), except as noted in (g).

(f) Separate welding procedure qualifications conducted in accordance with Section IX shall be required for this material.

(g) Minimum thickness, at the point where the tube is bent at the water inlet/outlet terminals, is 0.039 in. (1.0 mm), provided the tubes are enclosed by a shell, casing, or ducting, where such pipes or tubes are NPS 6 (DN 150) and less, and a proof test of the tubing is performed.

(h) All other applicable parts of Section IV shall apply.

(i) In case of conflict with any of the referenced specifications, this Code Case shall govern.

(j) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer’s Data Report.

Table 1
Chemical Composition of EN AW-6060 Alloy (AlMgSi)

Silicon	0.30–0.6
Iron	0.10–0.30
Copper	0.10 max.
Manganese	0.10 max.
Magnesium	0.35–0.6
Chromium	0.05 max.
Zinc	0.15 max.
Titanium	0.10 max.
Others, total	0.15 max.
Aluminum	Balance

GENERAL NOTE: Ref. EN 573-3:2007; Table 6, Aluminium alloys — 6 000 series — AlMgSi; page 16.

Table 2
Minimum Mechanical Properties

Temperature, °F	$R_{p0.2}$, ksi	R_m , ksi	Temperature, °C	$R_{p0.2}$, MPa	R_m , MPa	A50, %
68	7.3	17.4	20	50	120	14

GENERAL NOTE: Ref. UNI 9006-1:1988, para. 5.1, page 2.

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi
Up to 100	3.5
150	3.5
200	3.5
250	3.4
300	3.2

GENERAL NOTE: The maximum metal use temperature is 266°F (130°C). Data for 300°F and 150°C is provided for interpolation purposes.

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa
Up to 40	24.0
65	24.0
100	24.0
125	23.3
150	22.3

GENERAL NOTE: The maximum metal use temperature is 266°F (130°C). Data for 300°F and 150°C is provided for interpolation purposes.

Table 4
Applicable Specifications

UNI 9006-1, September 1988	Wrought primary aluminum and aluminum alloys. Aluminum-magnesium-silicon alloys. Al Mg 0.5 Si 0.4 Fe 0.2 (6060) alloy.
EN 515, August 1993	Aluminum and aluminum alloys. Wrought products. Temper designation.
EN 573-3, August 2007	Aluminum and aluminum alloys. Chemical composition and form of wrought products — Part 3: Chemical composition and form of products.
EN 755-1, March 2008	Aluminum and aluminum alloys. Extruded rod/bar, tube, and profiles. Part 1: Technical conditions for inspection and delivery.
EN 10002-1, July 2001	Metallic materials. Tensile testing. Part 1: Method of test at ambient temperature.

GENERAL NOTES:

- (a) See Section II, Part B, Appendix A for ordering information to obtain English copies.
- (b) Copy of the Italian Standard UNI 9006 can be obtained from: UNI, via Sannio 2, 20137 Milano, Italy.

Case 2628

Use of SB-241/SB-241M Grade 6063 T1 (UNS A96063) Aluminum Alloy Extruded (Integrally) Finned and Coiled Tube in the Manufacture of Hot Water Heating Boilers

(25)

Section IV

Approval Date: September 30, 2009

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SB-241/SB-241M Grade 6063 T1 (UNS A96063) aluminum alloy extruded finned and coiled tube meeting the chemical composition and mechanical properties of SB-241/SB-241M be used in construction for hot water heating boilers under the rules of Section IV?

Reply: It is the opinion of the Committee that SB-241/SB-241M Grade 6063 T1 (UNS A96063) aluminum alloy extruded finned and coiled tube meeting the chemical composition and mechanical properties in SB-241/SB-241M may be used in Section IV construction of hot water heating boilers under the following conditions:

(a) Maximum allowable working pressure shall not exceed 60 psi (413 kPa).

(b) The maximum water temperature shall be 250°F (120°C).

(c) The maximum allowable stresses are those given in [Tables 1](#) and [1M](#).

(d) The specified minimum tensile strength at room temperature shall be 17.0 ksi (115 MPa), the specified minimum yield strength shall be 9.0 ksi (60 MPa).

(e) Minimum thickness shall be 0.079 in. (2 mm), except as noted in (f).

(f) Minimum thickness, at the point where the tube is bent at the water inlet/outlet terminals, is 0.039 in. (1.0 mm), provided the tubes are enclosed by a shell, casing, or ducting where such pipes or tubes are NPS 6 (DN 150) and less, and a proof test of the tubing is performed.

(g) All other applicable parts of Section IV shall apply.

(h) This Case number shall be shown on the Manufacturer's Data report.

Table 1
Maximum Allowable Stress Values

For Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi
Up to 100	3.0
150	3.0
200	3.0
250	2.9
300	2.7

GENERAL NOTES:

(a) The allowable stress values are conservative annealed values to allow welding of the fins during construction.

(b) The maximum metal use temperature is 266°F. Data for 300°F is provided for interpolation purposes.

Table 1M
Maximum Allowable Stress Values

For Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa
Up to 40	20.7
65	20.7
100	20.7
125	20.2
150	18.7

GENERAL NOTES:

(a) The allowable stress values are conservative annealed values to allow welding of the fins during construction.

(b) The maximum metal use temperature is 130°C. Data for 150°C is provided for interpolation purposes.

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Case 2629

Alloy UNS N06690 Up To 1200°F (649°C)

Section VIII, Division 1

Approval Date: January 13, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed Ni-Cr-Fe Alloy (UNS N06690) seamless pipe and tube in sizes 5 in. O.D. and under that meet the requirements of SB-167 be used in Section VIII, Division 1, welded construction at temperatures above 850°F (454°C) up to and including 1200°F (649°C)?

Reply: It is the opinion of the Committee that solution annealed Ni-Cr-Fe alloy (UNS N06690) seamless pipe and tube in sizes 5 in. O.D. and under as described in the Inquiry may be used for Section VIII, Division 1 construc-

tion at temperatures above 850°F (454°C) up to and including 1200°F (649°C), provided the following additional requirements are met:

(a) The tubes shall be manufactured to SB-167 UNS N06690, cold worked, and annealed at 1900°F (1040°C) minimum.

(b) The maximum allowable stress values shall be those given in Section II, Part D, Table 1B for metal temperatures not exceeding 850°F (454°C) and [Tables 1](#) and [1M](#) for metal temperatures from 850°F (454°C) up to 1200°F (649°C).

(c) All material that is cold strained more than 5% during forming or fabrication shall be reannealed at a temperature of 1900°F (1040°C) minimum.

(d) This Case number shall be identified on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress, ksi [Note (1)]	
850	18.4	22.5
900	18.3	22.2
950	16.5 [Note (2)]	16.5 [Note (2)]
1000	11.6 [Note (2)]	11.6 [Note (2)]
1050	9.0 [Note (2)]	9.0 [Note (2)]
1100	6.5 [Note (2)]	6.5 [Note (2)]
1150	4.5 [Note (2)]	4.5 [Note (2)]
1200	3.0 [Note (2)]	3.0 [Note (2)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints, or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) Allowable stresses for temperatures of 950°F and above are values obtained from time-dependent properties.

Table 1M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress, MPa [Note (1)]	
475	127	154
500	126	127 [Note (2)]
525	95.0 [Note (2)]	95.0 [Note (2)]
550	71.4 [Note (2)]	71.4 [Note (2)]
575	54.3 [Note (2)]	54.3 [Note (2)]
600	41.4 [Note (2)]	41.4 [Note (2)]
625	30.6 [Note (2)]	30.6 [Note (2)]
650	19.7 [Note (2)], [Note (3)]	19.7 [Note (2)], [Note (3)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints, or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) Allowable stresses for temperatures of 500°C and above are values obtained from time-dependent properties.
- (3) The stress value at 650°C is provided for interpolation only. The maximum design temperature is stated in (b) of the Reply.

Case 2630

Use of Fatigue Analysis Screening, Method A For Vessels Made of 1.25Cr-0.5Mo-Si and 2.25Cr-1Mo Steels

Section VIII, Division 2

Approval Date: January 13, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the fatigue screening Method A in para. 5.5.2.3 be used for the vessels made of 1.25Cr-0.5Mo-Si and 2.25Cr-1Mo steels for Section VIII, Division 2 construction when the design allowable stress is governed by time-dependent properties?

Reply: It is the opinion of the Committee that the fatigue screening Method A in para. 5.5.2.3 may be used for the vessels made of 1.25Cr-0.5Mo-Si and 2.25Cr-1Mo steels for Section VIII, Division 2 construction when the design allowable stress is governed by time-dependent properties, provided that the following conditions are met:

- (a) The applicable materials are in [Table 1](#).
- (b) The allowable stress taken at operating conditions is governed by time-independent properties.
- (c) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Applicable Materials

Nominal Composition	Product Form	Spec. No.	Type/Grade	Class/Condition/Temp	Minimum Tensile Strength, MPa (ksi)
1.25Cr-0.5Mo-Si	Forgings	SA-182	F11	1	415 (60)
	Fittings	SA-234	WP11	1	415 (60)
	Seamless pipe	SA-335	P11	...	415 (60)
	Plate	SA-387	11	1	415 (60)
	Forgings	SA-182	F11	2	485 (70)
	Forgings	SA-336	F11	2	485 (70)
	Plate	SA-387	11	2	515 (75)
	Forgings	SA-336	F11	3	515 (75)
2.25Cr-1Mo	Seamless tube	SA-213	T22	...	415 (60)
	Fittings	SA-234	WP22	1	415 (60)
	Forgings	SA-182	F22	1	415 (60)
	Forgings	SA-336	F22	1	415 (60)
	Plate	SA-387	22	1	415 (60)
	Seamless pipe	SA-335	P22	...	415 (60)
	Forgings	SA-182	F22	3	515 (75)
	Forgings	SA-336	F22	3	515 (75)
	Plate	SA-387	22	2	515 (75)
	Forgings	SA-508	22	3	586 (85)
	Forgings	SA-541	22	3	586 (85)
	Plate	SA-542	B	4	586 (85)

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Case 2631

Titanium Aluminum Alloy, ASTM B367-08b, Ti 3Al-2.5V or Ti 3Al-2.5V-0.05Pd Castings

Section VIII, Division 1

Approval Date: December 14, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May titanium ASTM B367-08b, Gr. C-9 (Ti 3Al-2.5V) or C-18 (Ti 3Al-2.5V-0.05Pd) alloy castings be used in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that titanium alloy castings conforming to ASTM B367-08b, Grade C-9 (UNS R56320) or C-18 (UNS R56322) may be used in Section VIII, Division 1 construction, provided the following additional requirements are met:

(a) Supplementary Requirement S5 requiring hot isostatic pressing is mandatory.

(b) Supplementary Requirement S6 requiring tensile test of representative cast test bars is mandatory.

(c) The maximum allowable stress values shall be as shown in [Table 1](#) or [1M](#). These stress values are to be multiplied by casting quality factors of UG-24.

(d) The maximum design temperature shall be 600°F (316°C).

(e) Figure NFT-4 and corresponding Table NFT-4 shall be used for the materials.

(f) The base material shall be considered as P-No. 53 for purposes of welding procedure and performance qualifications conducted in accordance with Section IX.

(g) All other rules of Section VIII, Division 1, Part UNF applicable to titanium shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi, Grade C-9 or C-18
100	25.7
150	25.7
200	24.2
250	22.8
300	21.5
350	20.2
400	19.1
450	18.1
500	17.2
550	16.4
600	15.7

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa, Grade C-9 or C-18
40	177
65	177
100	165
125	156
150	147
175	140
200	133
225	126
250	120
275	115
300	111
325	107

GENERAL NOTE: The value for 325°C temperature is provided for interpolation purposes.

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Case 2632

Use of UNS N06625 Nickel Alloy (60Ni-22Cr-9Mo-3.5Cb) Annealed Grade 1 in Welded Tube, Plate, Sheet, and Strip

Section I

Approval Date: October 21, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS N06625 (60Ni-22Cr-9Mo-3.5Cb) conforming to SB-704 and SB-443 be used in Section I construction?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section I, providing the following additional requirements are met:

(a) The material shall be furnished in the annealed Grade 1 condition as listed in the specifications. The flat rolled alloy used to produce the tubing shall be UNS N06625 Grade 1 from SB-443.

(b) The maximum allowable stress values for plate, sheet and strip, and welded tube shall be as listed in Section II Part D, Table 1B for Section I for temperatures up to 1100°F (593°C). For higher temperatures the maximum allowable stress values shall be as listed in [Tables 1](#) and [1M](#) for plate, sheet and strip, and [Tables 2](#) and [2M](#) for welded tube. The maximum temperature shall not exceed 1200°F (649°C).

(c) Welding procedure and performance qualifications shall be conducted as prescribed in Section IX.

(d) For parameter y (see PG-27.4), the y values shall be as follows:

1150°F (620°C) and below, $y = 0.4$

1200°F (650°C), $y = 0.5$

(e) This Case number shall be identified in the Manufacturer's Data Report.

NOTE: Alloy UNS N06625 is subject to severe loss of impact strength at room temperature after exposure in the range of 1000°F to 1400°F (538°C to 760°C.)

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Maximum Allowable Stress Values for SB-443 Plate, Sheet, and Strip 120/60 ksi (T.S./Y.S.)

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
1150	21.0
1200	13.2

Table 1M
Maximum Allowable Stress Values for SB-443 Plate, Sheet, and Strip 825/415 MPa (T.S./Y.S.)

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
600	192
625	136
650	89.0

GENERAL NOTE: The value for 650°C temperature is provided for interpolation purposes.

Table 2
Maximum Allowable Stress Values for Welded SB-704 Tube 120/60 ksi (T.S./Y.S.)

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
1150	17.9
1200	11.2

Table 2M
Maximum Allowable Stress Values for Welded SB-704 Tube 825/415 MPa (T.S./Y.S.)

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
600	164
625	116
650	75.5

GENERAL NOTE: The value at 650°C temperature is provided for interpolation purposes.

Case 2634

Inspection Openings in Small Pressure Vessels

Section VIII, Division 1

Approval Date: December 14, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the provisions of UG-46(d), regarding inspection openings in pressure vessels, be waived, provided that such vessels are contained within sealed inaccessible chambers?

Reply: It is the opinion of the Committee that for vessels contained within sealed inaccessible chambers, the provisions of UG-46(d) may be waived, provided the following:

(a) The vessels are constructed from the following materials:

- (1) SA-240 Gr. 304L
- (2) SA-312 Gr. TP304L
- (3) SA-403 Gr. 304L
- (4) SA-240 Gr. 316L
- (5) SA-312 Gr. TP316L
- (6) SA-403 Gr. 316L
- (7) SA-240 Gr. 310S
- (8) SA-312 Gr. TP310S
- (9) SA-403 Gr. 310S
- (10) SB-265 Gr. 2

(11) SB-861 Gr. 2

(12) SB-363 Gr. WPT2

(13) SB-551 UNS R60702

(14) SB-658 UNS R60702

(b) The design pressure ranges from full vacuum to 320 psi (2.2 MPa).

(c) The minimum design metal temperature is not colder than 0°F (-18°C).

(d) The design temperature does not exceed 240°F (116°C).

(e) The vessels are not in cyclic service.

(f) "Leak before break" can be demonstrated by fracture mechanics analysis using $6t$ long through wall crack at an applied pressure of MAWP at MDMT.

(g) This Code Case is not used for vessels constructed to the rules of U-1(j).

(h) The inside diameter of the vessels does not exceed 12 in. (300 mm).

(i) The volume of the vessels do not exceed 4.0 ft³ (0.11 m³).

(j) A Professional Engineer shall provide a certification that such vessels will be enclosed within sealed inaccessible chambers.

(k) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2636

ASTM A240/A240M-09a UNS S30530 Solution Annealed Austenitic Stainless Steel Plate and Sheet

Section VIII, Division 1

Approval Date: January 13, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed ASTM A240/A240M-09a UNS S30530 austenitic stainless steel plate and sheet be used for welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that solution annealed ASTM A240/A240M-09a UNS S30530 austenitic stainless steel plate and sheet may be used for welded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UHA for austenitic stainless steels.

(b) The maximum allowable stress values for the material shall be those given in [Tables 1](#) and [1M](#). The maximum design temperature shall be 752°F (400°C).

(c) Separate welding procedure qualifications, conducted in accordance with Section IX, shall be required for this material. For the purposes of performance qualification, the material shall be considered P-No. 8, Group No. 1.

(d) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of ASTM A480/A480M-09, Table A1.2 shall apply.

(e) For external pressure design, Fig. HA-1 in Section II, Part D shall apply.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi
-20 to 100	20.0	20.0
200	16.8	19.8 [Note (1)]
300	15.3	19.0 [Note (1)]
400	14.3	18.6 [Note (1)]
500	13.6	18.4 [Note (1)]
600	13.0	17.6 [Note (1)]
650	12.6	17.1 [Note (1)]
700	12.2	16.5 [Note (1)]
750	11.7	15.8 [Note (1)]
800 [Note (2)]	11.1	14.9 [Note (1)]

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) This value is provided for interpolation only. The maximum design temperature is 752°F as shown in (b).

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa
-30 to 40	137	137
65	125	137 [Note (1)]
100	118	137 [Note (1)]
150	110	134 [Note (1)]
200	104	130 [Note (1)]
250	99.2	129 [Note (1)]
300	95.7	128 [Note (1)]
325	94.1	127 [Note (1)]
350	92.7	125 [Note (1)]
375	91.2	123 [Note (1)]
400	89.6	121 [Note (1)]

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Case 2639

25Cr-14Ni-Mo-Low C (UNS S30925) Seamless Austenitic Steel Tube

Section I

Approval Date: January 20, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution treated 25Cr-14Ni-Mo-Low C (UNS S30925) seamless austenitic stainless steel tube that conforms to applicable requirements in ASTM A213 and SA-213/SA-213M be used for steam service in Section I construction?

Reply: It is the opinion of the Committee that the material listed in the Inquiry may be used for steam service in Section I construction, provided the following requirements are met:

(a) The material shall meet the chemical analysis and minimum tensile requirements specified in ASTM A213 (UNS S30925) as applicable, except as shown in (b) and (c).

(b) The minimum solution treating temperature for this material shall be 1,920°F (1050°C).

(c) This material shall have a hardness not exceeding 256 HBW/270 HV (100 HRB).

(d) The rules of PG-19 for TP309S shall apply for this material, except that solution treatment, when required, shall be at the minimum temperature of 1,920°F (1050°C).

(e) The maximum allowable stress values for the material shall be as given in Table 1 and 1M. The maximum design temperature is 1,200°F (649°C).

(f) Separate welding procedure and performance qualification shall be conducted for the material in accordance with Section IX.

(g) This Case number shall be referenced in the documentation and recorded on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi
-20 to 100	25.3	25.3
200	21.3	25.3 [Note (1)]
300	19.5	24.9 [Note (1)]
400	18.3	23.9 [Note (1)]
500	17.5	23.2 [Note (1)]
600	16.8	22.6 [Note (1)]
650	16.5	22.3 [Note (1)]
700	16.2	21.9 [Note (1)]
750	15.9	21.5 [Note (1)]
800	15.6	21.1 [Note (1)]
850	15.4	20.8 [Note (1)]
900	15.1	20.4 [Note (1)]
950	14.9	20.1 [Note (1)]
1000	14.7	19.8 [Note (1)]
1050	14.5	19.2 [Note (1)]
1100	14.3	15.3 [Note (1)]
1150	9.7	9.7
1200	6.5	6.5

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 1M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa
-30 to 40	175	175
65	156	175 [Note (1)]
100	145	175 [Note (1)]
125	139	175 [Note (1)]
150	134	172 [Note (1)]
175	130	168 [Note (1)]
200	127	165 [Note (1)]
225	124	163 [Note (1)]
250	122	161 [Note (1)]
275	119	159 [Note (1)]
300	117	157 [Note (1)]
325	115	155 [Note (1)]
350	113	153 [Note (1)]
375	111	150 [Note (1)]
400	110	148 [Note (1)]
425	108	146 [Note (1)]
450	106	144 [Note (1)]
475	105	141 [Note (1)]
500	103	140 [Note (1)]
525	102	138 [Note (1)]
550	101	135 [Note (1)]
575	99.3	130 [Note (1)]
600	95.4	95.4
625	63.0	63.0
650	44.5	44.5 [Note (2)]

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only.

Case 2640-1

Postponement of Mandatory Date for Compliance

Section I

Approval Date: January 20, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to postpone, until July 1, 2013, the date for mandatory compliance with the requirements of Section I, 2007 Edition, 2009 Addenda, PG-69.1.6 for direct spring loaded pressure relief valves?

Reply: It is the opinion of the Committee that the date for mandatory compliance with the requirements of PG-69.1.6 of the 2009 Addenda to the 2007 Edition of Section I for direct spring loaded pressure relief valves may be postponed until July 1, 2013. Until that date, the requirements pertaining to capacity certification of direct spring loaded pressure relief valves for economizer service as presented in the 2007 Edition, up to and including the 2008 Addenda, of Section I shall apply. This Case number shall be included in addition to the markings required by PG-110.

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Case 2641

Titanium Nickel Molybdenum Alloy (Ti 0.8Ni-0.3Mo), Grade C-12 Castings

Section VIII, Division 1

Approval Date: December 14, 2009

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SB-367 titanium Grade C-12 (Ti 0.8Ni-0.3Mo, UNS R53400) alloy castings be used in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that SB-367 titanium, Grade C-12 alloy castings may be used in Section VIII, Division 1 construction, provided the following additional requirements are met:

(a) Supplementary Requirement S5 requiring hot isostatic pressing is mandatory.

(b) Supplementary Requirement S6 requiring tensile test of representative cast test bars is mandatory.

(c) The maximum allowable stress values shall be shown in [Table 1](#) or [1M](#). These stress values are to be multiplied by the casting quality factors of UG-24.

(d) The maximum design temperature shall be 600°F (316°C).

(e) Figure NFT-5 and the corresponding Table NFT-5 shall be used for the material.

(f) The base material shall be considered as P-No. 52 for purposes of welding procedure and performance specifications.

(g) All other rules for Section VIII, Division 1, Part UNF applicable to titanium shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values (Cast Product Forms)

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi
100	20.0
150	19.5
200	17.9
250	16.4
300	14.9
350	13.4
400	12.1
450	11.0
500	9.9
550	9.1
600	8.4

Table 1M
Maximum Allowable Stress Values (Cast Product Forms)

For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa
40	138
65	135
100	121
125	111
150	102
175	93.8
200	85.1
225	77.5
250	70.8
275	65.1
300	60.5
325	57.1

GENERAL NOTE: The value for 325°C temperature is provided for interpolation purposes.

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Case 2643-1

Use of UNS S32003 Ferritic/Austenitic Stainless Steel Plate, Pipe, and Tube

Section IV

Approval Date: October 6, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S32003 ferritic/austenitic stainless steel in SA-240 plate, SA-790 pipe, and SA-789 tube specifications be used in the construction of unlined Section IV, Part HLW water heaters and storage tanks?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the welded construction of Section IV, Part HLW water heaters and storage tanks, provided the following requirements are met:

(a) The material shall be furnished in the heat treated condition with the heat treatment as listed in the specification.

(b) The allowable stress for plate, seamless pipe, and seamless tube in accordance with SA-240, SA-790, and SA-789 shall be as listed in [Tables 1, 1M, 2, and 2M](#).

(c) The allowable stress for welded pipe and tube in accordance with SA-790 and SA-789 shall be as listed in [Tables 3, 3M, 4, and 4M](#).

(d) Welding procedure and performance qualification shall be conducted in accordance with Section IX.

(e) As an alternative to calculation using the listed stress values, the allowable working pressure of the water or storage tank may be established in accordance with the proof test provision of HLW-500.

(f) The maximum design temperature shall be 500°F (260°C).

(g) All other requirements of Section IV shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

NOTES:

- (1) This steel may be expected to develop embrittlement after service at moderately elevated temperatures; see Appendix A, A-340 and A-360, Section II, Part D.
- (2) This material may utilize the minimum thickness exceptions of HF-301.1(c).

Table 1
Maximum Allowable Stress Values
for SA-789 Tube (100 ksi T.S./70 ksi Y.S.)

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	25.0
200	24.3
300	22.8
400	22.6
500	22.6

Table 2
Maximum Allowable Stress Values for SA-240 Plate,
Seamless SA-790 Pipe (90 ksi T.S./65 ksi Y.S.)

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	22.5
200	21.8
300	20.5
400	20.3
500	20.3

Table 1M
Maximum Allowable Stress Values
for Seamless SA-789 Tube

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	172
65	172
100	165
125	160
150	157
175	156
200	155
225	155
250	155
275	155 [Note (1)]

NOTE: (1) The maximum use temperature shall be 260°C. The value at 275°C is provided for interpolation purposes.

Table 2M
Maximum Allowable Stress Values for SA-240 Plate and
Seamless SA-790 Pipe (90 ksi T.S./65 ksi Y.S.)

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	155
65	155
100	149
125	145
150	142
175	141
200	140
225	140
250	140
275	140 [Note (1)]

NOTE: (1) The maximum use temperature shall be 260°C. The value at 275°C is provided for interpolation purposes.

Table 3
Maximum Allowable Stress Values
for Welded SA-789 Tube (100 ksi T.S./70 ksi Y.S.)

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
100	21.3
200	20.6
300	19.4
400	19.2
500	19.2

NOTE: (1) For welded pipe and tube, the allowable stress values have been decreased by a factor of 0.85.

Table 4
Maximum Allowable Stress Values
for Welded SA-790 Pipe (90 ksi T.S./65 ksi Y.S.)

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
100	19.1
200	19.1
300	18.6
400	17.4
500	17.3

NOTE: (1) For welded pipe and tube, the allowable stress values have been decreased by a factor of 0.85.

Table 3M
Maximum Allowable Stress Values
for Welded SA-789 Tube (100 ksi T.S./70 ksi Y.S.)

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
40	146
65	146
100	141
125	136
150	134
175	133
200	132
225	132
250	132
275	132 [Note (2)]

NOTES:

- (1) For welded pipe and tube, the allowable stress values have been decreased by a factor of 0.85.
(2) The maximum use temperature shall be 260°C. The value at 275°C is provided for interpolation purposes.

Table 4M
Maximum Allowable Stress Values
for Welded SA-790 Pipe (90 ksi T.S./65 ksi Y.S.)

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
40	132
65	132
100	127
125	123
150	120
175	120
200	119
225	119
250	119
275	119 [Note (2)]

NOTES:

- (1) For welded pipe and tube, the allowable stress values have been decreased by a factor of 0.85.
(2) The maximum use temperature shall be 260°C. The value at 275°C is provided for interpolation purposes.

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Case 2645

Use of Carbon and Low Alloy Steel Plate, AS 1548-2008 Grades PT430N/PT430NR, PT460N/PT460NR, and PT490N/PT490NR

Section I; Section VIII, Division 1

Approval Date: March 10, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the carbon and low alloy steel grades PT430N/PT430NR, PT460N/PT460NR, and PT490N/PT490NR, conforming to the Australian Standard AS 1548-2008¹ be used for the manufacture of power boilers to Section I and pressure vessels to Section VIII, Division 1?

Reply: It is the opinion of the Committee that the grades of AS 1548-2008 described in the Inquiry may be used in Section I and Section VIII, Division 1 construction, provided the following requirements are met:

(a) The maximum allowable stress values shall be as given in [Tables 1](#) and [1M](#). The maximum design temperature is 1000°F (538°C).

(b) When normalized rolled (NR) plates are supplied, the finishing temperature of the plates, after final rolling, shall be above the upper transformation temperature (Ac3) of the material.

(c) Grades PT430 and PT460 shall be considered as P-No. 1, Group 1; Grade PT490 shall be considered as P-No. 1, Group 2.

(d) For the purpose of impact test requirements for Section VIII, Division 1 use, PT430NR and PT460NR shall be considered Curve B; PT430N and PT460N shall be considered Curve D; PT490N and PT490NR shall be considered Curve A per UCS-66.

(e) For external pressure applications, use Chart No. CS-2 of Section II, Part D.

(f) This Case number shall be referenced in the documentation and marking of the material, and recorded on the Manufacturer's Data Report.

¹See Section II, Part A, Nonmandatory Appendix A for ordering information to obtain a copy of AS 1548-2008.

Table 1
Maximum Allowable Stress Values, ksi

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi		
	PT430N, PT430NR	PT460N, PT460NR	PT490N, PT490NR
-20 to 100	17.9	19.0	20.3
150	17.9	19.0	20.3
200	17.9	19.0	20.3
250	17.9	19.0	20.3
300	17.9	19.0	20.3
400	17.9	19.0	20.3
500	17.9	19.0	20.3
600	17.9	19.0	20.3
650	17.9	19.0	20.3
700	16.9	16.9	18.3
750	13.9	13.9	14.8
800	11.4	11.4	12.0
850	8.7	8.7	9.3
900	5.9	5.9	6.7
950	4.0	4.0	4.0
1000	2.5	2.5	2.5

Table 1M
Maximum Allowable Stress Values, MPa

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa		
	PT430N, PT430NR	PT460N, PT460NR	PT490N, PT490NR
-30 to 40	123	131	140
65	123	131	140
100	123	131	140
125	123	131	140
150	123	131	140
200	123	131	140
250	123	131	140
300	123	131	140
325	123	131	140
350	123	129	139
375	114	114	123
400	95.0	95.1	101
425	79.6	79.6	83.8
450	63.2	63.2	67.0
475	45.3	45.3	51.0
500	31.7	31.7	33.6
525	21.9	21.9	21.3
550 [Note (1)]	12.7	12.7	12.9

NOTE: (1) These values are provided for interpolation purposes only. The maximum use temperature is 538°C.

Case 2649

Use of Capacitive Discharge Welding for Joining Non-Load-Bearing Attachments to P-No. 15E Group No. 1 Materials

Section I

Approval Date: July 2, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may capacitive discharge welding be used to join non-load-bearing attachments to P-No. 15E Group No. 1 materials without requiring postweld heat treatment in accordance with PW-39?

Reply: It is the opinion of the Committee that capacitive discharge welding may be used to join non-load-bearing attachments to P-No. 15E Group No. 1 materials without

postweld heat treatment in accordance with PW-39, provided the following requirements are met:

(a) The thickness of the non-load-bearing attachment shall not be thinner than 0.010 in. (0.25 mm).

(b) The energy input of the capacity discharge welding process shall not exceed 200 J.

(c) The maximum carbon content of the base metal is restricted to 0.15%.

(d) Prior to using the welding procedure, the Manufacturer shall verify that the heat-affected zone does not encroach upon the minimum wall thickness.

(e) This Case number shall be shown on the Manufacturer's Data Report or Manufacturer's Partial Data Report for the welded component.

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Case 2652-1

UNS N06696 Seamless Pipe, Tube, and Plate

Section I; Section VIII, Division 1

Approval Date: June 23, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May UNS N06696 seamless pipe and tube meeting the requirements of ASTM B167-11 and UNS N06696 plate in thickness of $\frac{3}{16}$ in. (4.76 mm) and over, and otherwise conforming to ASTM B168-11 be used for welded construction under the rules of Section I and Section VIII, Division 1?

Reply: It is the opinion of the Committee that UNS N06696 seamless pipe and tube meeting the requirements of ASTM B167-11 and UNS N06696 plate in thickness of $\frac{3}{16}$ in. (4.76 mm) and over, and otherwise conforming to ASTM B168-11 may be used for welded construction under the rules of Section I and Section VIII, Division 1, provided the following additional requirements are met:

(a) For plate, the minimum specified yield strength shall be 35 ksi (240 MPa); the minimum specified tensile strength shall be 85 ksi (586 MPa); and the minimum specified elongation in 2 in. (50 mm) shall be 30%.

(b) The material shall be solution annealed by heating to 2,100°F to 2,280°F (1 150°C to 1 250°C) followed by quenching in water or rapid cooling by other means.

(c) For Section I use, the y values [see Section I, PG-27.4, Note (6)] shall be as follows:

- (1) 1,050°F (565°C) and below: 0.4
- (2) 1,100°F (595°C): 0.5
- (3) 1,150°F (620°C) and above: 0.7

(d) For Section I use, the requirements for post-forming heat treatments after cold-working shall be the same as those for UNS N06600 in Table PG-19, except that heat treatment after cold-working shall be solution annealing according to the requirements of (b).

(e) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for nickel alloys.

(f) For Section VIII, Division 1 use, the requirements for post-forming heat treatments after cold-working shall be the same as those for UNS N06600 in Table UNF-79, except that heat treatment after cold-working shall be solution annealing according to the requirements of (b).

(g) The maximum allowable stress values for the material shall be those given in Tables 1 and 1M. For Section I, the maximum design temperature shall be 1,562°F (850°C). For Section VIII, Division 1, the maximum design temperature shall be 1,832°F (1 000°C).

(h) Separate welding procedure and performance qualifications conducted in accordance with Section IX shall be required for this material.

(i) Heat treatment after welding is neither required nor prohibited, but if it is performed it shall be solution annealing, according to the requirements of (b).

(j) For external pressure design, Fig. NFN-9 of Section II, Part D shall apply for temperatures not exceeding 1,650°F (900°C). The external pressure charts do not account for reduction of buckling strength due to creep under long-term loads. The effect of creep on buckling shall be considered at temperatures above 930°F (500°C).

(k) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
-20 to 100	23.3, 23.3
200	20.5, 23.3 [Note (2)]
300	18.6, 23.3 [Note (2)]
400	17.3, 23.3 [Note (2)]
500	16.3, 22.1 [Note (2)]
600	15.9, 21.5 [Note (2)]
650	15.8, 21.3 [Note (2)]
700	15.8, 21.3 [Note (2)]
750	15.8, 21.3 [Note (2)]
800	15.8, 21.3 [Note (2)]
850	15.8, 21.3 [Note (2)]
900	15.8, 21.3 [Note (2)]
950	15.8, 17.9 [Note (2)]
1,000	<i>14.1, 14.1</i>
1,050	<i>11.0, 11.0</i>
1,100	<i>8.6, 8.6</i>
1,150	<i>6.7, 6.7</i>
1,200	<i>5.2, 5.2</i>
1,250	<i>4.1, 4.1</i>
1,300	<i>3.2, 3.2</i>
1,350	<i>2.4, 2.4</i>
1,400	<i>1.8, 1.8</i>
1,450	<i>1.4, 1.4</i>
1,500	<i>1.1, 1.1</i>
1,550	<i>0.76, 0.76</i>
1,600 [Note (3)]	<i>0.59, 0.59</i>
1,650	<i>0.47, 0.47</i>
1,700	<i>0.37, 0.37</i>
1,750	<i>0.29, 0.29</i>
1,800	<i>0.23, 0.23</i>
1,850 [Note (4)]	<i>0.19, 0.19</i>

NOTES:

- (1) Values shown in italics are obtained from time-dependent properties.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (3) For Section I, this value is provided for interpolation only. The maximum design temperature for Section I is 1,562°F as shown in (g).
- (4) For Section VIII, Division 1, this value is provided for interpolation only. The maximum design temperature for Section VIII, Division 1 is 1,832°F as shown in (g).

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
-30 to 40	161, 161
65	148, 161 [Note (2)]
100	139, 161 [Note (2)]
125	134, 161 [Note (2)]
150	128, 161 [Note (2)]
175	124, 161 [Note (2)]
200	120, 160 [Note (2)]
225	116, 157 [Note (2)]
250	114, 153 [Note (2)]
275	112, 151 [Note (2)]
300	110, 149 [Note (2)]
325	109, 148 [Note (2)]
350	109, 147 [Note (2)]
375	109, 147 [Note (2)]
400	109, 147 [Note (2)]
425	109, 147 [Note (2)]
450	109, 147 [Note (2)]
475	109, 147 [Note (2)]
500	109, 135 [Note (2)]
525	<i>109, 109</i>
550	<i>87.0, 87.0</i>
575	<i>69.6, 69.6</i>
600	<i>55.6, 55.6</i>
625	<i>44.5, 44.5</i>
650	<i>35.5, 35.5</i>
675	<i>28.4, 28.4</i>
700	<i>22.8, 22.8</i>
725	<i>17.3, 17.3</i>
750	<i>13.9, 13.9</i>
775	<i>11.2, 11.2</i>
800	<i>8.97, 8.97</i>
825	<i>6.12, 6.12</i>
850	4.92, 4.92 [Note (3)]
875	<i>3.96, 3.96</i>
900	<i>3.20, 3.20</i>
925	<i>2.59, 2.59</i>
950	<i>2.10, 2.10</i>
975	<i>1.71, 1.71</i>
1000	<i>1.39, 1.39</i> [Note (4)]

NOTES:

- (1) Values shown in italics are obtained from time-dependent properties.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. The stress values in this range exceed 66 $\frac{2}{3}$ %, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (3) For Section I, the maximum design temperature is 850°C.
- (4) For Section VIII, Division 1, the maximum design temperature is 1000°C.

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Case 2653-1

F-Number Grouping for 63Ni-22Mo-15Cr Alloy (UNS N10362) Filler Metal

Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX

Approval Date: March 5, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternate rules may be applied to grouping UNS N10362 62Ni-22Mo-15Cr welding filler metal meeting the chemical requirements of [Table 1](#) but otherwise conforming to SFA-5.14 to reduce the number of welding procedures and performance qualifications?

Reply: It is the opinion of the Committee that UNS N10362 62Ni-22Mo-15Cr welding filler metal meeting the chemical requirements of [Table 1](#) but otherwise conforming to SFA-5.14 may be considered as F-No. 43 for both procedure and performance qualification purposes. Further, this material shall be identified as UNS N10362 in the welding procedure specification, procedure qualification record, and performance qualification records.

This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements (UNS N10362)

Element	Weight, %
Mo	21.5-23.0
Cr	13.8-15.6
Fe	1.25 max.
C	0.010 max.
Si	0.08 max.
Mn	0.60 max.
P	0.025 max.
S	0.010 max.
Ni	Remainder
Al	0.50 max.

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Case 2655-1

Elevated Temperature Design of Bolting

Section VIII, Division 2

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what rules may Section VIII, Division 2 (2007 edition and later) bolting be used for temperatures exceeding the limiting temperatures in Section II, Part D, Table 3 for Division 2?

Reply: It is the opinion of the Committee that pending development of complete rules for the evaluation of cyclic operation, bolting otherwise complying with the rules of Section VIII, Division 2, may be used for temperatures exceeding those in Section II, Part D, Table 3 for Division 2 under the following provisions.

(a) The allowable stress values for Division 2 may be extended to higher temperatures by using the values contained within Section II, Part D, Table 3 for Division 1.

(b) For a material approved for Division 2 application by a Case, the stress values may be extended to higher temperatures by using the values contained within

Section II, Part D, Table 3 for Division 1 or of a Case applicable to Division 1.

(c) The vessel or part is exempted from a fatigue analysis by the provisions of 5.5.2.2 of Division 2, and such exemption is made a part of the User's Design Specification.

(d) As an alternative to (c) for SB-637 UNS N07718 bolting, the vessel or part may be evaluated per Section III, Division 5, Subsection HB, Subpart B. The temperature limitation of 1,050°F or 550°C in Table HBB-I-14.12 applies.

(e) When using SB-637 UNS N07718 bolting, consideration shall be given to a reduction in toughness caused by long-term exposure at a temperature of 1,000°F (540°C) or greater.

NOTE: For metal temperatures exceeding those permitted in Section II, Part D, Table 3 for Division 2 applications, when both high membrane stress and high bending stress exist in the section, some inelastic straining due to creep in excess of the limits given in Appendix 1 of Section II, Part D, and Table P-1 of Appendix P of Section VIII, Division 1 may occur.

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Case 2658

Alternative Rules for Appendix 24 When Controlled Bolting Is Used

Section VIII, Division 1

Approval Date: September 8, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In Appendix 24, when controlled bolting (e.g., torque control or bolt tensioning) is specified for the clamp connection design bolt load, W , for the assembly condition, and for the design of bolt retainers and bolt redundancy, may alternative rules be used?

Reply: It is the opinion of the Committee that when controlled bolting is specified, the following alternative rules to those in Appendix 24 for the clamp connection design bolt load, W , for the assembly condition, and for the design of bolt retainers and bolt redundancy are acceptable.

(a) In place of the rules in para. 24-1(f) the design of bolt retainers and bolt redundancy shall be as follows:

Clamps designed to the rules of this Appendix shall be provided with a bolt retainer. The retainer shall be designed to hold the clamps together independently in the operating condition in case of failure of the primary bolting. Clamp hub friction shall not be considered as a retainer method. Multiple bolting (two or more

bolts per lug) is an acceptable alternative for meeting this requirement. See UG-35.2(b)(2) for additional guidance regarding redundancy of bolt retainers and redundant bolting.

(b) In addition to the rules in Appendix 24, consideration shall be given to loads other than pressure, such as piping loads that may act upon the clamp connection (see UG-22).

(c) Add the following below 24-4, eq. (5):

Alternatively, if controlled bolting (e.g., torque-control or bolt tensioning) techniques are used to assemble the clamp, the assembly design bolt load shall be taken as

$$W = 2A_m L S_a$$

(d) When controlled bolting techniques (e.g., torque control or bolt tensioning) are used to assemble the clamp, the Manufacturer shall provide to the user a copy of the controlled bolting instructions that were used. It is recommended that the Manufacturer refer to ASME PCC-1, Guidelines for Pressure Boundary Bolted Flange Joint Assembly. Furthermore, it is cautioned that bolt loads in excess of those using $W = 2A_m L S_a$ can overstress the clamp.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2659

Alternative Rules for Para. 4.17 When Controlled Bolting Is Used

Section VIII, Division 2

Approval Date: September 8, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In para. 4.17, when controlled bolting (e.g., torque control or bolt tensioning) is specified for the clamp connection design bolt load, W_o , for the assembly condition, and for the design of bolt retainers and bolt redundancy, may alternative rules be used?

Reply: It is the opinion of the Committee that under the conditions described in the Inquiry, the following clarifications and changes to the rules are acceptable.

(a) Add to para. 4.17.1 the following sentence:

Consideration shall be given to loads other than pressure, such as piping loads that may act upon the clamp connection (see 2.2.2.1).

(b) In place of 4.17.2.6, the following shall be used:

The design method used in this paragraph to calculate stresses, loads, and moments may also be used for designing clamp connections of shapes differing from those shown in Figs. 4.17.1 and 4.17.2, and for clamps consisting of more than two circumferential segments. The design equations in this paragraph may be modified when designing clamp connections of shapes differing from those in Figs. 4.17.1 and 4.17.2, provided that the basis for the modifications is in accordance with 1.1.1.2. The clamp connections designed in this manner shall be provided with a bolt retainer. The retainer shall be designed such that, in case of failure of the primary bolting, the retainer shall hold the clamps together independently for the operating condition. Multiple bolting (two or more bolts per lug) is an acceptable alternative for meeting the redundancy requirement. See 4.8.3.2 for additional requirements for bolt retainers and redundant bolting. No credit shall be taken for clamp hub friction toward satisfying this redundancy requirement.

(c) The following equation shall be used in lieu of eq. (4.17.9):

$$W_g = (A_m + A_b)S_{bg}$$

(d) After the equation for W_g , insert the following:

Alternatively, if controlled bolting (e.g., torque-control or bolt tensioning) techniques are used to assemble the clamp, the assembly design bolt load may be taken as

$$W_g = 2 \times A_m \times S_{bg}$$

In addition, the Manufacturer shall provide to the user a copy of the bolting instructions that were used. It is recommended that the Manufacturer refer to ASME PCC-1, Guidelines for Pressure Boundary Bolted Flange Joint Assembly. It is cautioned that bolt loads in excess of those calculated using $W_g = 2 \times A_m \times S_{bg}$ can overstress the clamp.

(e) In 4.17.6, the definitions of A_b and A_m shall be as follows:

A_b = total cross-sectional area of the bolts per clamp lug based on the root diameter or the least diameter of the unthreaded portion, if less

A_m = total cross-sectional area of the bolts per clamp lug

The definitions of W_g , W_{g1} , W_{g2} , and W_o shall be as follows:

W_g = total clamp connection design bolt load on both lugs for the gasket seating and assembly condition

W_{g1} = total clamp connection design bolt load on both lugs for the gasket seating condition

W_{g2} = total clamp connection design bolt load on both lugs for the assembly condition

W_o = total clamp connection design bolt load on both lugs for the design condition

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2660

F-Number Grouping for 57Ni-30Cr-9Fe-1.8Nb Filler Metal (UNS N06043)

Section IX

Approval Date: September 8, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternate rules may be applied to grouping 57Ni-30Cr-9Fe-1.8 Nb (UNS N06043) welding filler metals meeting the chemical requirements of [Table 1](#), but otherwise conforming to SFA-5.14 to reduce the number of required welding procedures and performance qualifications?

Reply: It is the opinion of the Committee that 57Ni-30Cr-9Fe-1.8Nb (UNS N06043) welding filler metals meeting the chemical requirements of [Table 1](#), but otherwise conforming to SFA-5.14 may be considered as F-No. 43 for both procedure and performance qualification purposes, with these materials being identified as 57Ni-30Cr-9Fe-1.8Nb (UNS N06043) in the welding procedure specification, procedure qualification record, and performance qualification records. This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
C	0.04 max.
Mn	3.0 max.
Fe	7.0–12.0
P	0.020 max.
S	0.015 max.
Si	0.50 max.
Cu	0.30 max.
Ni	Remainder
Co	...
Al	0.50 max.
Ti	0.50 max.
Cr	28.0–31.5
Nb(Cb) Plus Ta	1.0 to 2.5 [Note (1)]
Mo	0.50 max.
V	...
W	...
Other Elements Total	0.50 max.

NOTE: (1) Nb(Cb) range is 1.0–2.5. Ta is 0.10 maximum.

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Case 2661-2

Use of SA-723/SA-723M Forgings, SA-705/SA-705M Forgings, and SA-564/SA-564M Bar for Bolting

Section VIII, Division 3

Approval Date: April 23, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the following materials be used for Section VIII, Division 3 construction?

(a) for fabrication of bolting

(1) SA-723/SA-723M forgings, Grades 1, 2 and 3; Classes 1 and 2

(2) SA-564/SA-564M bar, Type XM-13, Conditions H1150 and H1150M; Type XM-12, Conditions H1075, H1100, and H1150; Type 630, Conditions H1100 and H1150; Type XM-25, Conditions H1100 and H1150

(3) SA-705/SA-705M forgings, Type XM-13, Conditions H1150 and H1150M; Type XM-12, Conditions H1075, H1100, H1150, and H1150M; Type 630, Conditions H1100, H1150, and H1150M; Type XM-25, Conditions H1100 and H1150

(b) for fabrication of washers

(1) SA-564/SA-564M bar, Type XM-12, Conditions H925 and H1025; Type 630, Conditions H1025 and H1075

(2) SA-705/SA-705M forgings, Type XM-12, Conditions H925 and H1025; Type 630, Conditions H1025 and H1075

Reply: It is the opinion of the Committee that the materials described in the Inquiry may be used for fabrication of bolting for Section VIII, Division 3 construction, provided the following additional requirements are met:

(a) SA-723/SA-723M and Type XM-12, Conditions H925 and H1075 materials shall have a maximum measured yield strength not in excess of 25 ksi (170 MPa) above the specified minimum.

(b) For washers made of Type XM-12, Condition H925, Note (9) in Table KM-400-2 and Table KM-400-2M shall also apply.

(c) Impact testing shall be in accordance with the requirements of KM-212.1 and KM-230, except that impact tests are also required for material to be used for the fabrication of nuts. The impact energy requirements in Table KM-234.2(b) shall apply.

(d) The limits on stress intensity shall be in accordance with KD-621, except that the yield strength values, S_y , shall be obtained from Section II, Part D, Table Y-1 for the specified grade and class or condition of material that will be used for the bolting.

(e) All requirements in Tables KM-400-1, KM-400-1M, KM-400-2, and KM-400-2M for the material to be used for bolting, including the maximum design temperature and cautionary notes, shall apply.

(f) All heat treatment shall be conducted prior to cutting or rolling the threads.

(g) This Case number shall be shown on the certification of the material and on the Manufacturer's Data Report.

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Case 2663

Use of ASTM A106/A106M-08 as SA-106/SA-106M

Section I; Section IV; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section XII

Approval Date: December 7, 2010

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May ASTM A106/A106M-08 be used in Sections I; IV; VIII, Divisions 1, 2, and 3; and XII welded construction in lieu of SA-106/SA-106M?

Reply: It is the opinion of the Committee that ASTM A106/A106M-08 may be used in Sections I; IV; VIII, Divisions 1, 2, and 3; and XII welded construction in lieu of SA-

106/SA-106M, provided the following additional requirements are met:

(a) The rules of the applicable construction code, division, and part for SA-106/SA-106M shall apply.

(b) The allowable stresses, external pressure chart, physical properties, P-Number, and Group number for SA-106/SA-106M applicable for the section, division, and part of the selected construction code, found in Section II, Part D shall apply.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2665-1

57Ni-22Cr-14W-2Mo-La Alloy (UNS N06230)

Section I

Approval Date: July 13, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May UNS N06230 wrought plate, sheet, and strip; forgings; welded pipe and tube; seamless pipe and tube, and wrought fittings be used in molten nitrate salt wetted Section I construction?

Reply: It is the opinion of the Committee that solution annealed alloy UNS N06230 wrought plate, sheet, and strip; forgings; welded pipe and tube; seamless pipe and tube; and wrought fittings as listed in [Table 1](#), but otherwise conforming to the rules of Section I may be used in molten nitrate salt wetted service, provided the following additional requirements are met:

(a) The maximum allowable stress values for the material that shall be used are those found in Section II, Part D, Table 1B for both U.S. Customary and SI Units.

(b) The maximum design temperature is 1,300°F (704°C).

(c) This Case number shall be recorded on the Manufacturer's Data Report.

Table 1
Product Specifications

Forgings	SB-564
Plate, sheet, and strip	SB-435
Seamless pipe and tube	SB-622
Welded pipe	SB-619
Welded tube	SB-626
Wrought fittings	SB-366

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Case 2666

Exemption From Postweld Heat Treatment for SA-268 TP439 P-No. 7 Tube to SA-790 Alloy UNS S31803 P-No. 10H Header Welds

Section I

Approval Date: January 12, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-268 TP439 P-No. 7 tube to SA-790 alloy UNS S31803 header welds be exempt from postweld heat treatment requirements of PW-39?

Reply: It is the opinion of the Committee that SA-268 TP439 P-No. 7 tube to SA-790 alloy UNS S31803 header welds may be exempted from postweld heat treatment requirements of PW-39 under the following conditions:

(a) The SA-268 TP439 tubes shall be limited in carbon content to 0.010% maximum.

(b) The SA-268 TP439 tubes shall be no larger than 1.500 in. (38.1 mm) outside diameter nor have a nominal wall thickness greater than 0.125 in. (3.2 mm).

(c) The header shall be SA-790 alloy UNS S31803 and shall be no larger than NPS 3 $\frac{1}{2}$ (DN 90) nor have a nominal thickness greater than 0.318 in. (8.1 mm).

(d) The weld used to join the tube to the header shall be a combination groove and fillet weld with the combined nominal thickness not greater than 0.500 in. (13 mm) made using the GTAW process with SFA-5.9 ER2209 filler metal, with multiple stringer passes, and not exceeding 350°F (177°C) interpass temperature.

(e) The design pressure shall not exceed 100 psig (700 kPa), and the design temperature shall not exceed 400°F (204°C).

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2668-1

Use of SA-268 Grades UNS S43932 and UNS S43940 Conforming to SA-268 in the Manufacture of Heating Boilers

Section IV

Approval Date: January 31, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SA-268 Grades UNS S43932 and UNS S43940 in the form of seamless and welded ferritic stainless steel tubing for general service, be used in the construction of Section IV hot water heating boilers?

Reply: It is the opinion of the Committee that SA-268 Grades UNS S43932 and UNS S43940 in the form of seamless and welded ferritic stainless steel tubing for general service may be used in the construction of heating boilers, under the following conditions:

(a) The maximum water temperature shall be 210°F (99°C).

(b) The maximum metal temperature shall be 300°F (150°C).

(c) The maximum allowable stresses are those given in Tables 1 and 1M, 2, and 2M for Grade UNS S43932, and Tables 3, 3M, 4, and 4M for Grade UNS S43940.

(d) All other applicable parts of Section IV shall apply.

(e) For UNS S43932 and UNS S43940, use of P-No. 7 materials shall apply.

(f) This Case number shall be shown on the Manufacturer's Data Report.

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
Less than 100	12.0
150	11.8
200	11.4
250	11.3
300	11.2

Table 1M
Maximum Allowable Stress for Grade UNS S43932, Seamless SA-268 Tube, Plate, and Strip

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
Less than 40	85.5
65	84.5
100	83.2
125	81.6
150	79.0

Table 2
Maximum Allowable Stress Values for Grade UNS S43932, SA-268 Welded Tube and Pipe

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
Less than 100	10.2
150	10.0
200	9.7
250	9.6
300	9.5

Table 2M
Maximum Allowable Stress Values for Grade UNS S43932, SA-268 Welded Tube and Pipe

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
Less than 40	72.6
65	71.8
100	70.7
125	69.3
150	67.1

Table 3
Maximum Allowable Stress Values for Grade UNS S43940, SA-268 Seamless Tube, Plate, and Strip

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
Less than 100	10.5
150	10.4
200	10.2
250	10.1
300	9.7

Table 4
Maximum Allowable Stress Values for Grade UNS S43940, SA-268 Welded Tube and Pipe

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
Less than 100	10.2
150	10.0
200	9.7
250	9.6
300	9.5

Table 3M
Maximum Allowable Stress Values for Grade UNS S43940, SA-268 Seamless Tube, Plate, and Strip

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
Less than 40	82.7
65	81.3
100	78.6
125	77.8
150	77.2

Table 4M
Maximum Allowable Stress Values for Grade UNS S43940, SA-268 Welded Tube and Pipe

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
Less than 40	70.3
65	69.1
100	66.7
125	66.1
150	65.6

Case 2671-2

57Ni-22Cr-14W-2Mo-La Alloy (UNS N06230), Subpart 3, Fig. NFN-24 Up to 1,800°F (982°C)

Section I; Section II, Part D; Section VIII, Division 1

Approval Date: December 18, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed 57Ni-22Cr-14W-2Mo-La alloy (UNS N06230) wrought sheet, plate, strip, rod, welded pipe and tube, wrought fittings, seamless pipe and tube, and forgings conforming to the specifications listed in Section II, Part D, Subpart 1, Table 1B be used under external pressure represented in Fig. NFN-24 and as modified by this Case to 1,800°F (982°C) and conform to the rules of Section II, Part D, Subpart 1, Table 1B?

Reply: It is the opinion of the Committee that solution annealed 57Ni-22Cr-14W-2Mo-La alloy (UNS N06230) wrought sheet, plate, strip, rod, welded pipe and tube, wrought fittings, seamless pipe and tube, and forgings as described in the *Inquiry* may be used under external pressure in Fig. NFN-24 up to 1,800°F (982°F) curves (see Note) shown in [Figures 1](#) and [1M](#) and [Tables 1](#) and [1M](#) and conforming to the rules of assigned construction codes listed in Section II, Part D, Subpart 1, Table 1B.

This Case number shall be shown on the Manufacturer's Data Report.

NOTE: The external pressure charts do not account for reduction of buckling strength due to creep under long-term loads. The effect of creep under on buckling shall be considered at temperatures for which allowable stresses are shown italicized in Tables 1A, 2A, 2B, 5A, and 5B of Section II, Part D, Subpart 1.

Figure 1
External Pressure Chart up to 1,800°F

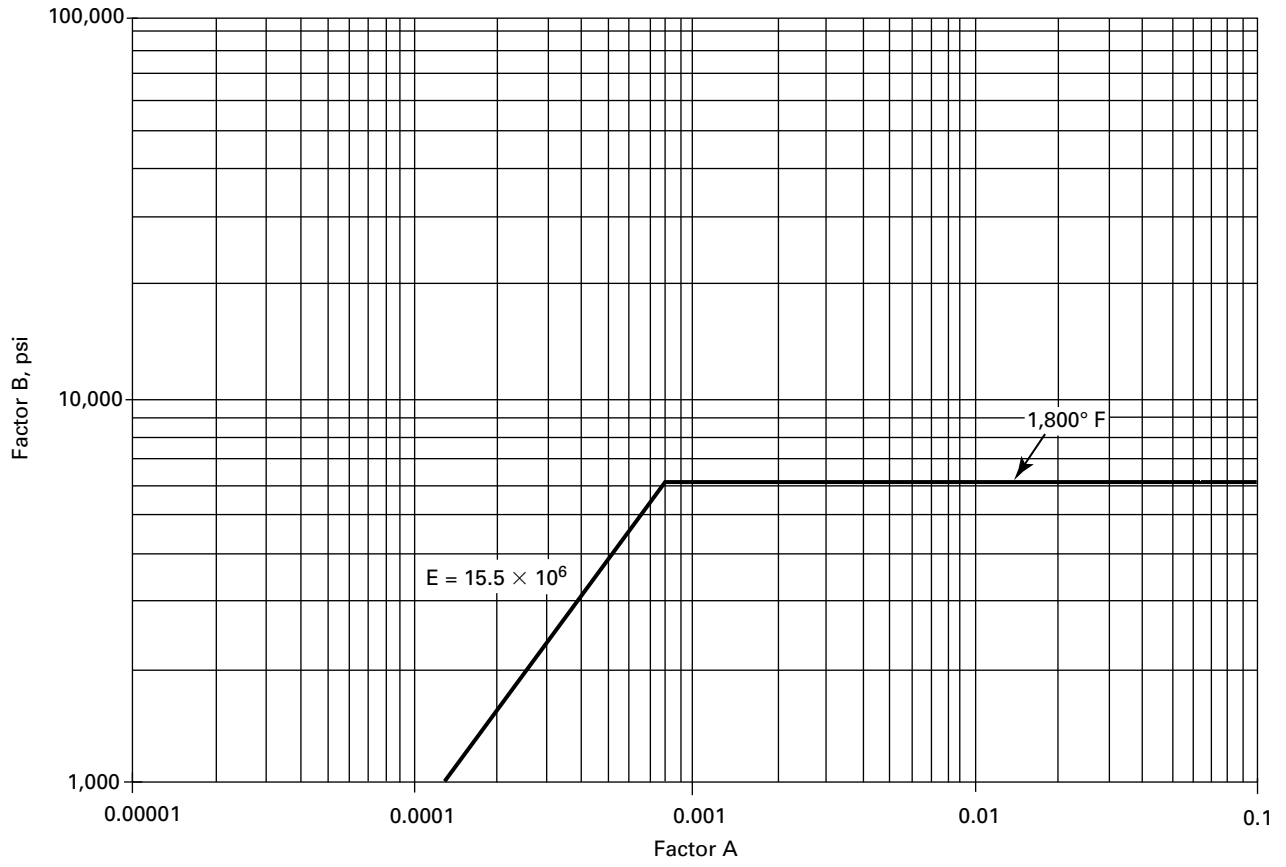


Figure 1M
External Pressure Chart up to 982°C

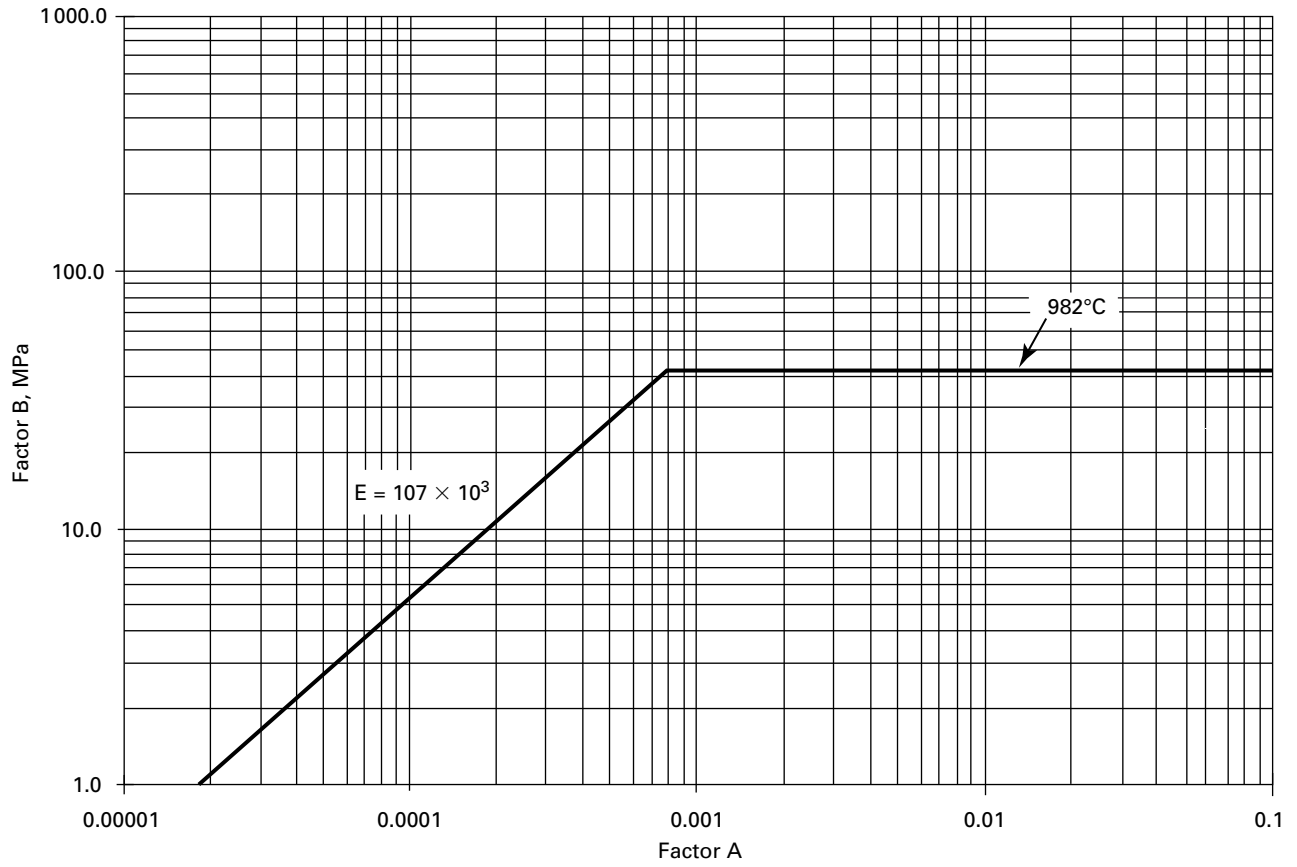


Table 1
Tabular Values for Figure 1

Temperature, °F	A	B, psi
1,800	1.00E-05	78
	1.29E-04	1,000
	7.87E-04	6,100
	1.00E-01	6,100

Table 1M
Tabular Values for Figure 1M

Temperature, °C	A	B, MPa
982	1.00E-05	0.5
	1.87E-05	1
	1.29E-04	6.9
	7.87E-04	42.1
	1.00E-01	42.1

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Case 2672

37Ni-33Fe-25Cr Alloy (UNS N08120) Welded Construction Above 1650°F to 1800°F

Section VIII, Division 1

Approval Date: June 16, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed 37Ni-33Fe-25Cr alloy (UNS N08120) wrought sheet, plate, strip, rod, welded pipe and tube, wrought and welded fittings, seamless pipe and tube, and forgings conforming to the requirements in the specifications listed in [Table 1](#) be used for Section VIII, Division 1 welded construction above 1650°F (899°C) up to and including 1800°F (982°C)?

Reply: It is the opinion of the Committee that solution annealed 37Ni-33Fe-25Cr alloy (UNS N08120) wrought sheet, plate, strip, rod, welded pipe and tube, wrought and welded fittings, seamless pipe and tube, and forgings as described in the *Inquiry* may be used in welded construction above 1650°F (899°C) up to and including 1800°F (982°C) complying with the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The maximum allowable stress values shall be those given in [Tables 2](#) and [2M](#). For pipe, tube, and fitting products welded without filler, a joint efficiency factor of 0.85 shall be used.

(b) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. Filler metals shall be limited to the following materials for welding to itself: UNS R30556, N06002, W86002, N06617, W86117, and N06231.

(c) Heat treatment after forming or fabrication is neither required nor prohibited except as required in (e).

(d) The rules in Subsection C that shall apply are those given in Part UNF for nickel alloys.

(e) The requirements for post-forming heat treatment after cold-working shall be the same as those for UNS N08800 in [Table UNF-79](#), except that heat treatment after cold-working shall be solution annealing at a minimum temperature of 2150°F (1177°C).

(f) The physical properties for UNS N08120 are given in [Table 3](#) and [Table 3M](#) for density, thermal diffusivity, thermal conductivity, dynamic modulus of elasticity, mean coefficient of thermal expansion, and Poisson's ratio.

(g) This Case number shall be recorded on the Manufacturer's Data Report.

Table 1
Product Specifications

Product	Specification
Fittings	SB-366
Forgings	SB-564
Plate, sheet, and strip	SB-409
Rod, bar	SB-408
Seamless pipe and tube	SB-407
Welded pipe	SB-514
Welded tube	SB-515

Table 2
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
1700	0.96
1750	0.72
1800	0.54

NOTE: (1) Values are obtained from time-dependent properties.

Table 2M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
925	6.75
950	5.21
975	3.99
1000	3.04 [Note (2)]

NOTES:

(1) Values are obtained from time-dependent properties.

(2) The maximum use temperature for this grade is 982°C, and the value listed at 1000°C is provided for interpolation purposes only.

Table 3
Physical Properties

Temperature, °F	Density, lb/in. ³	Thermal Diffusivity, ft ² /hr	Thermal Conductivity, Btu/hr-ft-°F	Dynamic Modulus of Elasticity, ×10 ⁶ psi	Mean Coefficient of Thermal Expansion 78°F to Temp., ×10 ⁻⁶ in./in./°F
Room	0.291	0.118	6.5	28.6	...
200	...	0.125	7.0	28.2	8.0
400	...	0.135	8.0	27.2	8.3
600	...	0.145	9.0	26.3	8.6
800	...	0.158	10.1	24.9	8.8
1000	...	0.168	11.2	23.6	9.0
1200	...	0.178	12.5	22.5	9.3
1400	...	0.185	14.0	21.3	9.5
1600	...	0.188	15.0	20.0	9.7
1800	...	0.195	15.9	18.8	9.9
2000	...	0.205	17.1	...	...
2200	...	0.215	18.0	...	...

GENERAL NOTE: Poisson's Ratio = 0.31

Table 3M
Physical Properties

Temperature, °C	Density, kg/m ³	Thermal Diffusivity, ×10 ⁻⁶ m ² /sec	Thermal Conductivity, W/(m-°C)	Dynamic Modulus of Elasticity, ×10 ³ MPa	Mean Coefficient of Thermal Expansion 25°C to Temp., ×10 ⁻⁶ mm/mm/°C
Room	8070	3.04	11.4	197	...
100	...	3.24	12.7	194	14.3
200	...	3.48	14.1	188	14.9
300	...	3.72	15.4	182	15.3
400	...	3.97	17.1	174	15.8
500	...	4.22	18.7	165	16.1
600	...	4.47	21.0	159	16.4
700	...	4.69	23.3	152	16.9
800	...	4.81	24.9	143	17.3
900	...	4.88	26.2	136	17.6
1000	...	5.07	28.0	128	17.8
1100	...	5.29	29.6	...	...
1200	...	5.55	...	...	...

Case 2673

Tolerance for External Pressure Design Conditions

Section VIII, Division 2

Approval Date: June 16, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the requirements for measurement of out-of-roundness in para. 4.4.4 be waived?

Reply: It is the opinion of the Committee that the requirements for measurement of out-of-roundness in para. 4.4.4 may be waived, provided the following conditions are met.

(a) For cylindrical shell, t/r shall be greater than 0.02, and for spherical shell and hemispherical head, t/r shall be greater than 0.01, where

r = outer radius

t = nominal thickness of cylindrical shell, spherical shell, and hemispherical head

(b) The maximum allowable external pressure calculated in accordance with paras. 4.4.5 and 4.4.7, respectively, shall be more than five times the required design external pressure.

(c) The external pressure to be stamped on the name plate shall be no greater than 20% of the calculated maximum allowable external pressure.

(d) If the cylindrical shell, spherical shell, and hemispherical head are subjected to uniform axial compression and axial compression due to bending moment, the allowable stress calculated in accordance with para. 4.4.12 shall be more than five times the stress due to combined loading.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2674-1

Use of SA/EN 10028-2, Grade 13CrMoSi5-5+QT Steels for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use steel plates manufactured in accordance with SA/EN 10028-2 Grade 13CrMoSi5-5+QT in the construction of pressure vessels under the rules of Section VIII, Division 2, Class 2?

Reply: It is the opinion of the Committee that that steel plates manufactured in accordance with SA/EN 10028-2 Grade 13CrMoSi5-5+QT may be used in Section VIII, Division 2, Class 2 construction, provided the additional requirements are met:

(a) The design temperature shall not exceed 1058°F (570°C).

(b) This material shall conform to SA-20/SA-20M, Table 1 whenever Table 1 is more restrictive.

(c) The maximum allowable stress values shall be as given in [Tables 1](#) and [1M](#).

(d) The material shall be considered as P-No. 4, Group No. 1.

(e) For external pressure design, use Fig. CS-3 of Section II, Part D.

(f) For physical properties in Section II, Part D, this material shall be considered as 1¹/₄Cr-¹/₂Mo-Si alloy.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)] for Thickness range, in.		
	Up to 2.25 incl.	2.25 to 4 incl.	4 to 10 incl.
100	30.8	30.2	29.6
150	30.8	30.2	29.6
200	30.8	30.2	29.6
250	30.8	30.2	29.6
300	30.8	30.2	29.6
350	30.8	30.2	29.6
400	30.8	30.2	29.6
450	30.8	30.2	29.6
500	30.8	30.2	29.6
550	30.8	30.2	29.6
600	30.8	30.2	29.6
650	30.8	30.2	29.6
700	30.8	30.2	29.4
750	30.3	29.5	28.7
800	29.5	28.8	28.0
850	20.2	20.2	20.2
900	13.7	13.7	13.7
950	9.3	9.3	9.3
1,000	6.3	6.3	6.3
1,050	4.2	4.2	4.2
1,100 [Note (2)]	2.8	2.8	2.8

GENERAL NOTE: This material may be susceptible to temper embrittlement. See Section II, Part D, Appendix A, A-250.

NOTES:

- (1) Allowable stresses for temperatures of 850°F and above are values obtained from time-dependent properties.
- (2) These values are provided for interpolation purposes only. The maximum use temperature is 1,058°F.

Table 1M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)] for Thickness range, mm		
	Up to 60 incl.	60 to 100 incl.	100 to 250 incl.
40	213	208	204
65	213	208	204
100	213	208	204
125	213	208	204
150	213	208	204
175	213	208	204
200	213	208	204
225	213	208	204
250	213	208	204
275	213	208	204
300	213	208	204
325	213	208	204
350	213	208	204
375	213	208	202
400	209	203	198
425	204	199	194
450	199	194	189
475	104	104	104
500	73.7	73.7	73.7
525	52.0	52.0	52.0
550	36.3	36.3	36.3
575 [Note (2)]	25.2	25.2	25.2

GENERAL NOTE: This material may be susceptible to temper embrittlement. See Section II, Part D, Appendix A, A-250.

NOTES:

- (1) Allowable stresses for temperatures of 475°C and above are values obtained from time-dependent properties.
- (2) These values are provided for interpolation purposes only. The maximum use temperature is 570°C.

Case 2675-1

Use of Noncode Pressure Relief Valves

Section VIII, Division 1

Approval Date: August 30, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: When overpressure protection by system design is used per Section XIII, 13.3, under what conditions may a user utilize a pressure relief valve without a Certification Mark to provide overpressure protection for a vessel whose MAWP is less than 15 psi and stamped in accordance with Division 1?

Reply: It is the opinion of the Committee that when overpressure protection by system design is used per Section XIII, 13.3, a user may utilize a pressure relief valve without a Certification Mark to provide overpressure protection for a vessel whose MAWP is less than 15 psi and stamped in accordance with Division 1, provided the following conditions are met:

(a) The decision to use a pressure relief valve without a Certification Mark is the responsibility of the user. Acceptance by the jurisdiction may be required. The user shall request that the Manufacturer's Data Report state that overpressure protection is provided by system design per this Code Case number. This Case number shall also be applied to a metal tag that is attached with a wire to the pressure relief valve.

(b) The user shall evaluate the acceptability of the pressure relief valve without a Certification Mark for the application and its expected performance by comparing it to appropriate relief valve design, construction, performance, and installation requirements in Section VIII, Division 1: UG-150(e), UG-154(a)(1), UG-155(e), UG-155, UG-156(a), UG-156(b), UG-156; Section XIII: Part 3, 3.2.13(c), 3.9, 9.1.2, 9.1.3, 9.1.4(a), 9.2.1(a), 9.2.1(b), 9.2.2(a), 9.2.2(a)(1), 9.2.2(b), 9.2.3, 9.2.4, and 9.7. The results of the evaluation shall be incorporated into the documentation required in (f).

(c) The user shall conduct a detailed analysis to identify and examine all scenarios that could result in an overpressure condition and magnitude of the overpressure. The causes of overpressure as described in ANSI/API Standard 21, Pressure-Relieving and Depressuring Systems, shall be

considered. Other standards or recommended practices that are more appropriate to the specific application may also be considered. A multidisciplinary team experienced in methods such as hazards and operability analysis (HazOp); failure modes, effects, and criticality analysis (FMECA); "what-if" analysis; or other equivalent methodology shall conduct the analysis.

(d) The overpressure scenario shall be readily apparent so that operators or protective instrumentation will take corrective action to prevent operation above the MAWP at the coincident temperature.

(e) The combination of the pressure relief valve's set pressure, set pressure tolerance, and required overpressure shall not exceed 116% of the MAWP times the ratio of the allowable stress value at the temperature of the overpressure scenario to the allowable stress value at the design temperature. The overpressure limit shall not exceed the test pressure. Credible events or scenario analysis as described in WRC Bulletin 498, "Guidance on the Application of Code Case 2211 — Overpressure Protection by Systems Design" shall be considered.

(f) The results of the analysis shall be documented and signed by the individual in responsible charge of the management of the operation of the vessel. This documentation shall include as a minimum the following:

(1) detailed process and instrument flow diagrams (P&IDs), showing all pertinent elements of the system associated with the vessel

(2) a description of all operating and upset scenarios, including those involving fire and those that result from operator error, and equipment and/or instrumentation malfunctions

(3) a detailed description of any safety critical instrumentation used to limit the system pressure, including the identification of all truly independent redundancies and a reliability evaluation (qualitative or quantitative) of the overall safety system

(4) an analysis showing the maximum pressure that can result from each of the scenarios

(5) the evaluation of the acceptability of the pressure relief valve without a Certification Mark

(6) this Code Case number

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Case 2676

Alternative Procedure for Calculating Allowable Axial Compressive Stress in Cylindrical Shells Constructed of 2¹/₄Cr-1Mo Steel at Temperatures Greater Than 700°F and Less Than or Equal to 1000°F

Section VIII, Division 1

Approval Date: June 16, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may cylindrical shells constructed of 2¹/₄Cr-1Mo steel be designed for axial compression for design temperatures greater than 700°F and less than or equal to 1000°F?

Reply: It is the opinion of the Committee that cylindrical shells constructed of 2¹/₄Cr-1Mo steel may be designed for axial compression for design temperatures greater than 700°F and less than or equal to 1000°F, provided the following requirements are met:

(a) The maximum allowable longitudinal compressive stress shall be the smaller of the following values:

- (1) the maximum allowable tensile stress value permitted for the material at the design temperature
- (2) the value of the factor B determined by the following procedure

E = modulus of elasticity of material obtained from [Figures 1](#) and [1M](#)

$$K_1 = \frac{5}{5 - 0.3048 \ln(T)}$$

R_o = outside radius of cylindrical shell or tube

t = minimum required thickness of the cylindrical shell or tube

T = number of operating hours. The minimum value of T (for hot tensile) is equal to 1.0 hr, and the maximum value is equal to 500,000 hr.

Step 1. Using the selected values of t and R_o , calculate the value of factor A using the following formula:

$$A = \frac{0.125}{(R_o/t)} K_1$$

Step 2. Using the value of A calculated in [Step 1](#), enter external pressure chart, [Figures 1](#) and [1M](#) (see also [Tables 1](#) and [1M](#)). Move vertically to an intersection with the material/time line. Interpolation may be made between lines for intermediate times. If tabular values are used, interpolation may be used to determine a B value that lies between two adjacent tabular values for a specific number of hours. Such interpolation methods may also be used to determine a B value at an intermediate number of hours that lie between two sets of tabular values, after first determining B values for each set of tabular values.

In cases where the value at A falls to the right of the end of the material/time line, assume an intersection with the horizontal projection of the upper end of the material/time line. If tabular values are used, the last (maximum) tabulated value shall be used. For values of A falling to the left of the material/time line, see [Step 4](#).

Step 3. From the intersection obtained in [Step 2](#), move horizontally and read the value of factor B . This is the maximum allowable compressive stress for the values of t and R_o used in [Step 1](#).

Step 4. For values of factor A falling to the left of the applicable material/time line, the value of B shall be calculated using the following formula:

$$B = AE/2$$

Step 5. Compare the value of B determined in [Step 3](#) and [Step 4](#) with the computed longitudinal compressive stress in the cylindrical shell or tube, using the selected values of t and R_o . If the value of B is smaller than the computed compressive stress, a greater value of t must be selected and the procedure repeated until a value of B is obtained that is greater than the compressive stress computed for the loading on the cylindrical shell or tube.

(b) This Case number shall be recorded in the Remarks section of the Manufacturer's Data Report.

Figure 1
External Pressure Chart for 2¼Cr-1Mo Steel (Annealed) at 1,000°F

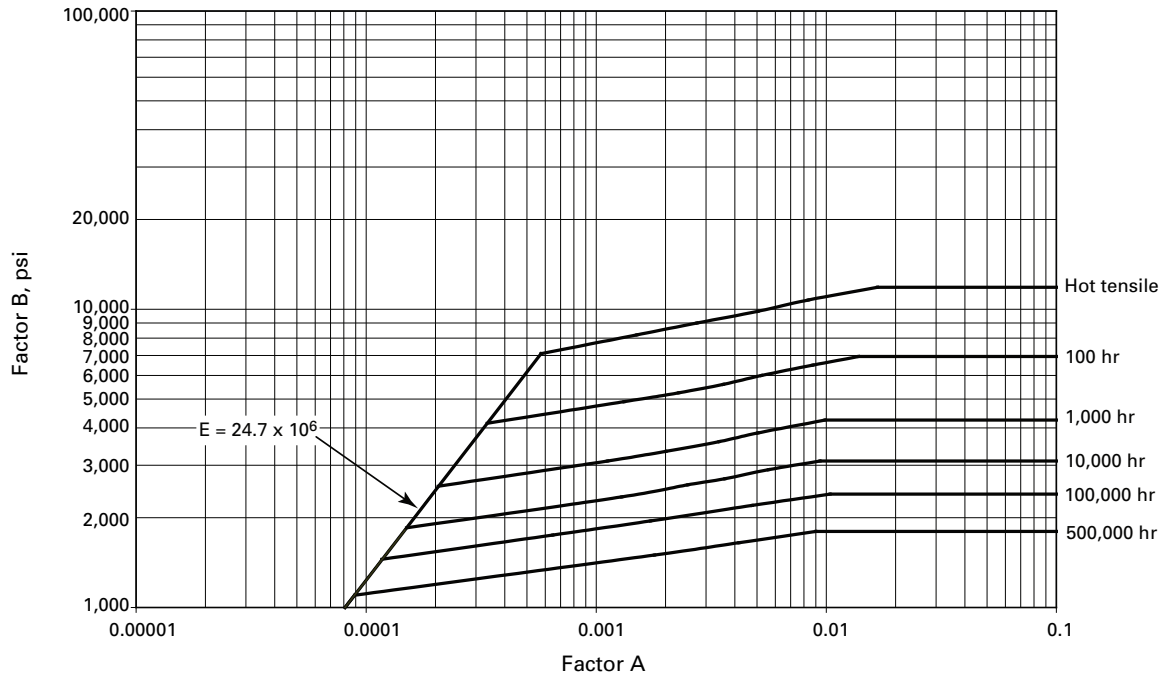


Figure 1M
External Pressure Chart for 2¼Cr-1Mo Steel (Annealed) at 538°C

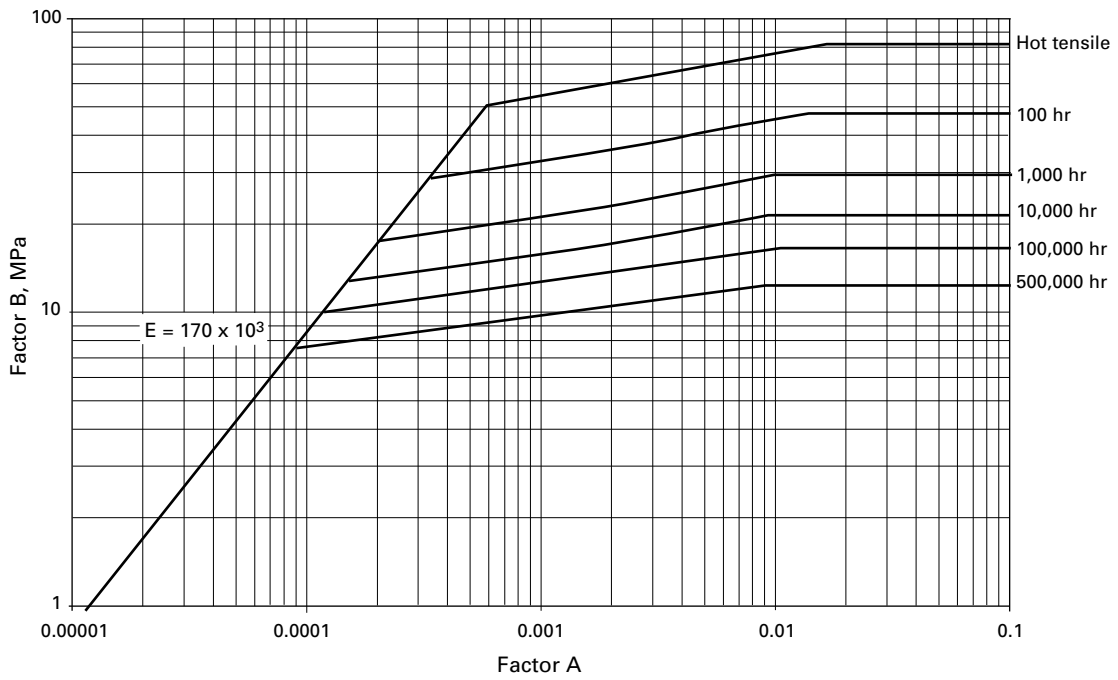


Table 1
Tabular Values for Figure 1

Time, hr	A	B, psi	Time, hr	A	B, psi	
Hot tensile	1.00E-05	124	10,000	1.00E-05	124	
	8.10E-05	1,000		8.10E-05	1,000	
	5.75E-04	7,100		1.50E-04	1,850	
	1.50E-03	8,200		1.29E-03	2,350	
	2.74E-03	9,000		2.50E-03	2,580	
	5.05E-03	9,850		3.62E-03	2,700	
	8.35E-03	10,750		5.61E-03	2,900	
	1.67E-02	11,850		9.39E-03	3,100	
	1.00E-01	11,850		1.00E-01	3,100	
	100	1.00E-05		124	100,000	1.00E-05	124
8.10E-05		1,000	8.10E-05	1,000		
3.36E-04		4,150	1.17E-04	1,450		
1.32E-03		4,900	6.47E-04	1,750		
2.28E-03		5,250	1.72E-03	1,950		
3.57E-03		5,600	4.76E-03	2,200		
5.22E-03		6,000	1.04E-02	2,400		
8.72E-03		6,500	1.00E-01	2,400		
1.38E-02		6,950	500,000	1.00E-05		124
1.00E-01		6,950		8.10E-05		1,000
1,000	1.00E-05	124	500,000	8.91E-05	1,100	
	8.10E-05	1,000		1.79E-03	1,500	
	2.06E-04	2,550		4.17E-03	1,650	
	1.12E-03	3,100		9.00E-03	1,800	
	2.01E-03	3,340		1.00E-01	1,800	
	3.42E-03	3,600				
	5.04E-03	3,850				
	9.88E-03	4,250				
	1.00E-01	4,250				

Table 1M
Tabular Values for Figure 1M

Time, hr	A	B, MPa	Time, hr	A	B, MPa
Hot tensile	1.00E-05	1	10,000	1.00E-05	1
	8.10E-05	7		8.10E-05	7
	5.75E-04	49		1.50E-04	13
	1.50E-03	57		1.29E-03	16
	2.74E-03	62		2.50E-03	18
	5.05E-03	68		3.62E-03	19
	8.35E-03	74		5.61E-03	20
	1.67E-02	82		9.39E-03	21
	1.00E-01	82		1.00E-01	21
100	1.00E-05	1	100,000	1.00E-05	1
	8.10E-05	7		8.10E-05	7
	3.36E-04	29		1.17E-04	10
	1.32E-03	34		6.47E-04	12
	2.28E-03	36		1.72E-03	13
	3.57E-03	39		4.76E-03	15
	5.22E-03	41		1.04E-02	17
	8.72E-03	45		1.00E-01	17
	1.38E-02	48		1.00E-05	1
1,000	1.00E-01	48	500,000	8.10E-05	7
	1.00E-05	1		8.91E-05	8
	8.10E-05	7		1.79E-03	10
	2.06E-04	18		4.17E-03	11
	1.12E-03	21		9.00E-03	12
	2.01E-03	23		1.00E-01	12
	3.42E-03	25			
	5.04E-03	27			
	9.88E-03	29			
1.00E-01	29				

Case 2677

Welding of Aluminum Alloy Tube-to-Tubesheet Joints by Friction Stir Welding (FSW) Process

Section VIII, Division 1

Approval Date: April 6, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may friction stir welding (FSW), including the use of mechanical pressure inherent to the FSW process, be used for welding tube-to-tubesheet joints constructed using the aluminum alloys listed in Table UNF-23.1 under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that friction stir welding (FSW), including the use of mechanical pressure inherent to the FSW process, may be used for welding tube-to-tubesheet joints constructed using the aluminum alloys listed in Table UNF-23.1 under the rules of Section VIII, Division 1, provided that the following requirements are met.

1 TESTS AND EXAMINATIONS

(a) *Procedure Qualification Specimens.* Figure 1 shows an acceptable type of friction stir tube-to-tubesheet joint in the as-welded condition. The forge zone is principally the region where the metal has been “stirred” by the probe of the weld tool, but it also extends to the region that is mechanically modified by the shoulder of the tool. The weld dimensions follow the nomenclature of UW-20.1.

Figure 2 shows a weld in which the surface has been machined to remove surface roughness and flashing left by the shoulder, and to round-off the internal edge of the tube. In this case the weld leg, a_g , is measured to the final machined surface.

A tube-to-tubesheet weld demonstration qualification mockup assembly, consisting of ten mockup welds, shall be prepared and examined in accordance with Section IX, QW-193, except that the acceptance criteria shall be as follows:

(1) *Visual Examination.* The accessible surfaces of the welds shall be examined visually with no magnification required. The weld track shall show complete contact across the width of the shoulder. Depression of the shoulder-track is acceptable, and of locally deeper

areas, provided that the tool subsequently climbs out of any local surface depression. Weld track depression that will be removed by machining and has no impact upon the design tubesheet thickness is acceptable regardless of depth. However weld track depressions that will not be removed by machining, and any probe exit holes must be allowed for in the tubesheet design.

Weld-flash at the edge of the weld-track is acceptable provided that it is less than 0.025 in. (0.6 mm) in thickness, measured at the lip, without further analysis. However greater flash thickness shall be allowable if permitted by the design.

The tube inside surface shall show no deformation or collapse beyond any allowed in the design.

(2) *Liquid Penetrant Examination.* After visual examination, the rough surfaces of the forge zone shall be removed and etched in preparation for liquid penetrant testing.

(-a) Surface removal to clean may be by machining or sanding to a maximum depth of 0.03 in. (0.7 mm) maximum below the shoulder track, but not to exceed 25% of the probe length, and extending at least 0.5 in. (12 mm) beyond all test-tube weld edges.

(-b) The machined surface shall be etched to remove 0.0002 in. (0.005 mm) to 0.0004 in. (0.01 mm) of metal, followed by a water rinse. The etch rate may be determined by experiment on tube or tubesheet base metal, or by published data from the etchant manufacturer for the same alloy. After etch and rinse, the surface shall be deoxidized using dilute nitric acid, rinsed and dried, and thereafter handled only with dry cotton gloves prior to penetrant testing.

(-c) After surface preparation, liquid penetrant examination and acceptance standards shall meet the requirements of Appendix 8, except that section 8-5, Repair Requirements shall not be mandatory, provided that the repair is to be made using a qualified friction-stir repair procedure.

(3) *Macroexamination.* The mockup welds shall be sectioned through the center of the tube for macroexamination. The four exposed surfaces shall be smoothed and etched with a suitable etchant (see QW-470) to give a clear definition of the weld forge zone. If the weld perimeter incorporates regions with multiple weld passes, additional welds shall be made and sectioned to provide

four exposed surfaces showing the minimum number of weld passes, and four more showing the maximum number of passes.

Using a nominal 10× magnification, the exposed cross sections of the weld shall confirm

(-a) minimum leak path dimension, dimension a_g of Figure 1 and 2, as required by the design

(-b) no voids, inconsistencies, or joint line remnants

(-c) consolidation within the forge zone and at the sides, to the tube wall, and to the tubesheet

(b) *Welding*. Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs) shall address the requirements specified in section 2, Essential Variables. The original and any required renewal of a welder's or welding operator's performance qualifications shall be performed in accordance with QW-303.5.

(c) *Shear Load Test*. The allowable loads for welds made in accordance with this code case shall be established using the rules provided by Appendix A, except that the no-test option of Table A-2 will not apply under any circumstance, and the shear strength test will be established, in every case, using the rules of sections A-3 and A-4.

2 ESSENTIAL VARIABLES

All of the Tube-to-Tubesheet Qualification Essential Variables listed in Section IX, QW-288.1 shall be replaced by the following:

(a) a change in tube or tubesheet material specification, type, grade, or temper condition.

(b) for tubesheets with a nominal thickness less than or equal to 2.0 in. (51 mm), the minimum qualified tubesheet thickness shall be 0.9 times the thickness used for procedure qualification. There is no upper limit to the maximum thickness qualified. For tubesheets thicker than 2.0 in. (51 mm), thickness is not an essential variable.

(c) the minimum qualified ligament width shall be not less than 90% of the ligament width used for the procedure qualification. The maximum qualified ligament width is unlimited. Ligament width greater than $\frac{3}{8}$ in. (9.5 mm) is not an essential variable.

(d) a change in tube nominal outside diameter.

(e) the minimum qualified tube thickness shall be the thickness used for procedure qualification. The maximum qualified tube thickness shall be no greater than 1.1 times the thickness used for the procedure qualification.

(f) a change in the method of preparing the base metal surfaces prior to welding (e.g., changing from mechanical cleaning to chemical cleaning or to abrasive cleaning or vice versa) or a change in the type or application method for any solvent used immediately prior to welding. As a minimum for welds made under this Case, the base metal surface preparation shall remove all debris and visible surface oxides, and thereafter the surfaces shall be

kept in an air-conditioned and condensation-free environment until welding is complete.

(g) a change, including material type (but not including temper), in a plug or tooling that supports the inside surface of the tube during welding. In the case of a tube support plug where plug material may become incorporated into the forge zone, the plug nominal chemical composition must match either the tube or tubesheet material.

(h) a change from tubes expanded in the tubesheet to unexpanded, or an increase in the diametral clearance between the tube and tubesheet greater than 0.01 in. (0.3 mm), subject to an absolute maximum clearance of 0.03 in. (0.8 mm). A reduction in radial clearance, or a change to add tube expansion is not a significant variable, except that shear testing will be required if the design requires the change in order to provide an allowable shear load greater than that originally qualified.

(i) a change in the number of segments that make up the weld track around the tube circumference, or in the number of duplicate passes over any portion of any segment(s).

(j) a change from "as welded" to PWHT within a specified temperature range, or vice versa.

(k) a change in the rotating tool, its shape, its coating material, if any, or its operation, from that used during qualification, beyond the following limits:

(1) a change in the tool and any applied coating material(s) specifications or nominal chemical composition, or a reduction in minimum hardness

(2) shoulder:

(-a) a change in diameter greater than 10%

(-b) a change in surface or concavity profile greater than 0.005 in. (0.1 mm) at any point on the contact surface

(3) probe:

(-a) a change in diameter greater than 5%

(-b) a change in radial eccentricity greater than 0.002 in. (0.05 mm)

(-c) a change in length greater than 5%

(-d) a change in taper semi-cone angle greater than 3 deg

(-e) flutes, if applicable (see Figure 3 for an example):

(-1) a change in number

(-2) a change in pitch angle greater than 5 deg

(-3) a change in flute channel radius greater than 10%

(-4) a change in flute depth greater than 0.005 in. (0.1 mm)

(-f) threads, if applicable (see Figure 4 for an example): a change in thread form, pitch, or in the number of thread starts

(-g) flats, if applicable

(-1) a change in number

(-2) a change in flat surface profile, relative to that used in qualification, greater than 0.010 in. (0.3 mm) at any location

(-h) tip: a change in the surface profile from that qualified greater than 0.002 in. (0.05 mm)

(4) a change in the direction of tool rotation, or a change in speed of rotation greater than +10% or -2% of that used for qualification.

(5) for FSW under force control only, except at the starting and stopping points:

(-a) a change in the axial force applied to the tool during welding greater than 10%

(-b) a change in the lateral force applied to the tool during welding greater than 10%

(6) for FSW under position control only: an increase in travel speed greater than 5%, except at the starting and stopping points

(7) a change in tool angular tilt greater than 1 deg relative to the direction of tool (probe tip) motion, except at the starting and stopping points

(l) a change in welding equipment:

(1) a change from direct visual control to remote visual control, or vice versa

(2) a change in the method of tool path control, e.g., a change from numerical electro-hydraulic servo-control to analog (tracer) servo-control or to hard metallic guide-way control

(m) an increase in the elapsed time between the start of base metal surface cleaning and weld completion, over that during qualification, except as follows:

(1) For elapsed times of 48 hr or less, elapsed time is not a significant variable.

(2) Requalification of a qualified procedure for the sole purpose of extending the allowable elapsed time shall be permissible by completion of new shear tests made with the extended elapsed time.

(3) Figure 5 shows the placement of the probe relating to the joint line that provides good mixing in the stir-zone, which is associated with freedom from residual oxide defects. For tool paths that provide centered seam alignment or seam alignment on the advancing (good mixing) side of the probe at every location around the tube perimeter, elapsed time is not an essential variable.

(n) a change in the location of the probe axis relative to the interface between the tube and tube sheet more than 20% of the probe diameter, except at path transitions from one tube's weld to another.

3 PRODUCTION WELD QUALITY

Production welds shall only be made by qualified operators using certified welding equipment and qualified weld procedures. Welding machines and data logging equipment shall be certified for operational accuracy using standards that are traceable to NIST. Certification for making welds under this Case shall expire no more than 1 yr after the date of calibration. Production weld quality shall be evaluated by visual observation of the welding process, by monitoring of welding variables, and by gas bubble leak test.

(a) Welding variables shall be monitored during welding operations. Monitoring may be by using operator alarms or by conducting a postweld review of variable data records from the FSW machine or from separate data recording equipment.

(b) Weld tracking (relative to tube perimeter) shall be either monitored visually during welding operations, or controlled by machine setup to reference points on the tubesheet to ensure concentricity of the tool path to the tube axis.

(c) Weld penetration shall be verified by the visible appearance of the tool's shoulder track and/or weld flash at the periphery of the shoulder track.

(d) Drift in the probe operating variables listed above, including speed of rotation, axial force, lateral force, travel speed, and tool angular tilt shall be allowable provided that the following limits are not exceeded:

(1) Variable drift less than or equal to 200% of the limit provided for the same variable in section 2, para. 2(k) shall be acceptable provided that the accumulated duration of the periods in excess of the limit does not exceed 0.25 sec within any 10 sec welding interval.

(2) Variable drift greater than 200% of the stated limits is unacceptable for any duration when it applies to welding tool operation unless such drift is attributable to instrumentation or data collection errors.

(e) Production welds shall be subject to a gas-bubble test and leakage evaluation by application of bubble forming solution at operating pressure in accordance with Section V, Article 10, Appendix I, Bubble Test — Direct Pressure Technique. Welds showing evidence of leakage shall be marked and retested after repairs have been made. Welds shall be acceptable provided that:

(1) They were made by a qualified operator using a certified machine and qualified procedure.

(2) The operator judged the welds to be following the intended track, to have the intended penetration to completion, and confirmed that the probe operational parameters were maintained within the allowed limits during welding.

(3) They showed no evidence of leakage during gas bubble testing.

Welds that would be acceptable except for having exceeded the elapsed time, between base metal preparation and the completion of welding, as indicated in section 2, para. 2(m) shall become acceptable upon completion of a requalification with the extended elapsed time in accordance with section 2, para. 2(m). Welds not meeting the requirements of section 3, paras. (a) through (e) shall be repaired using a qualified repair procedure.

4 REPORT

This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Acceptable Friction Stir Welded Tube-to-Tubesheet Joint

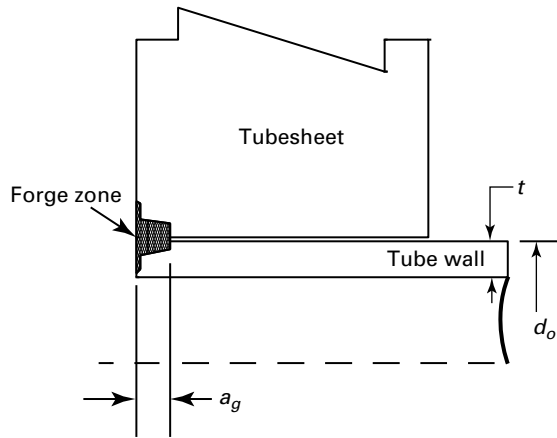


Figure 3
Example of Probe With Flutes

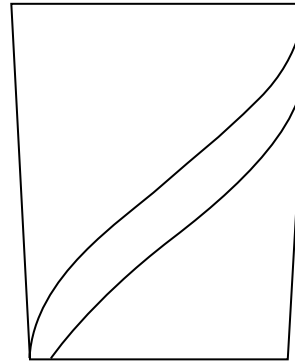


Figure 4
Example of Probe With Thread

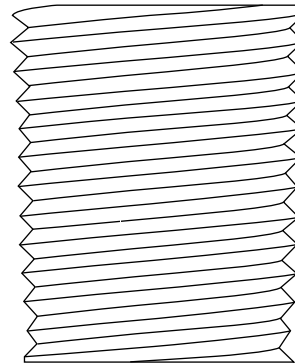


Figure 2
Weld Leg Dimension After Optional Surface Cleanup

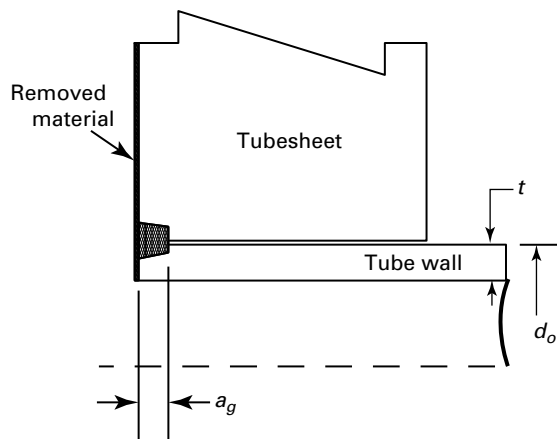
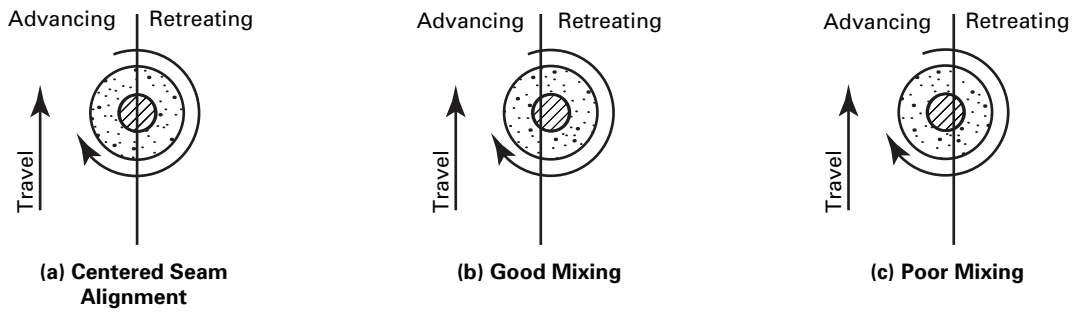


Figure 5
Typical Centered Seam Alignment, Good Mixing by Placing Seam on Advancing Side of Probe, Poor Mixing by Placing Seam on Retreating Side of Probe



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Case 2678-1

Replacement Parts for Pressure Vessels

Section VIII, Division 3

Approval Date: September 26, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May replacement parts for pressure vessels constructed to Section VIII, Division 3 for which Partial Data Reports with a nameplate or stamping are required be constructed using the Edition and Addenda used for the original construction of the vessel or any subsequent Edition and Addenda?

Reply: It is the opinion of the Committee that replacement parts for pressure vessels constructed to Section VIII, Division 3 for which Partial Data Reports with a nameplate or stamping are required may be constructed using the Edition and Addenda used for the original construction or any subsequent Edition and Addenda, provided the following additional requirements are met:

(a) Replacement parts shall meet all applicable requirements of the User's Design Specification for the pressure vessel that the part will be used in.

(b) Changes to Code rules made subsequent to the Code Edition, Addenda, and cases established for construction of the replacement part may be critical to the integrity of the part in the intended service. The Manufacturer shall review these changes and shall implement any that are identified as critical to the integrity of the part in the intended service. The Manufacturer shall describe any changes that are made in the remarks section of Form

K-2. The Authorized Inspector shall verify that the review has been made by the Manufacturer.

(c) Replacement parts shall have a design pressure equal to or greater than the design pressure of the pressure vessel that the part will be used in.

(d) Replacement parts shall have a coincident design metal temperature equal to or greater than (i.e., warmer than) the coincident design metal temperature of the pressure vessel that the part will be used in.

(e) Replacement parts shall have a minimum design metal temperature equal to or less than (i.e., colder than) the minimum design metal temperature of the pressure vessel that the part will be used in.

(f) If the design pressure, coincident design metal temperature, or the minimum design metal temperature is different from the pressure vessel that the part will be used in, a supplementary nameplate shall be applied immediately adjacent to the nameplate on the replacement part.

(g) The supplementary nameplate shall have characters no less than $\frac{5}{16}$ in. (8 mm) high and shall be attached to the part in the same manner as the part nameplate.

(h) The supplementary nameplate shall state: "REPLACEMENT PART. DESIGN CONDITIONS OF THE VESSEL THAT THIS PART IS USED IN ARE SHOWN ON THE ORIGINAL VESSEL NAMEPLATE."

(i) This Case number shall be shown on the Manufacturer's Design Report and the Manufacturer's Data Report as applicable.

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Case 2679

Implementing in Parts 4 and 5 the Changes in ASCE/SEI 7-10, Paras. 2.3.2 and 2.4.1 for Wind Load Factors

Section VIII, Division 2

Approval Date: June 16, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the Table 4.1.2 and Table 5.3, Design Load Combinations and Table 5.4 and Table 5.5, Load Case Combinations including W (Wind Loads) be revised as shown in this Code Case?

Reply: It is the opinion of the Committee that the Table 4.1.2 and Table 5.3, Design Load Combinations and Table 5.4 and Table 5.5, Load Case Combinations including W (Wind Loads) may be revised as follows:

(a) Part 4

(1) Table 4.1.2, Design Load Combinations:

(-a) In fifth, sixth, and seventh rows, change W to $0.6W$.

(-b) Replace existing Note (3) with the following:

This load combination addresses an overturning condition for foundation design. It does not apply to design of anchorage (if any) to the foundation. Refer to ASCE/SEI 7-10, 2.4.1 Exception 2 for an additional reduction to W that may be applicable.

(2) In para. 4.1.5.3(b), add the following:

The factors for wind loading, W in Table 4.1.2, Design Load Combinations, are based on ASCE/SEI 7-10 wind maps and probability of occurrence.

(3) In Table 4.1.1, after *Wind Loads*, add the following:
See para. 4.1.5.3(b).

(b) Part 5

(1) At the end of para. 5.1.3.2, add the following:

The factors for wind loading, W in Table 4.1.2, Design Load Combinations, are based on ASCE/SEI 7-10 wind maps and probability of occurrence.

(2) In Table 5.2, after *Wind Loads*, add the following:
See para. 5.1.3.2.

(3) In Table 5.3, Design Load Combinations (5), (6), and (8), change W to $0.6W$.

(4) In Table 5.3, replace existing Note (2) with the following:

This load combination addresses an overturning condition for foundation design. It does not apply to design of anchorage (if any) to the foundation. Refer to ASCE/SEI 7-10, 2.4.1, Exception 2 for an additional reduction to W that may be applicable.

(5) In Table 5.4, Load Combination (3), change $0.86W$ to $0.54W$.

(6) In Table 5.4, Load Combination (4), change $1.7W$ to $1.1W$.

(7) In Table 5.5, Load Combination (3), change $1.4W$ to $0.86W$.

(8) In Table 5.5, Load Combination (4), change $2.7W$ to $1.7W$.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2680

Other Recognized Standards for Definition of Wind and Earthquake Loading in Lieu of ASCE/SEI 7

Section VIII, Division 2

Approval Date: June 16, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use recognized load definition standards other than ASCE/SEI 7 for determination of the Design Load Parameters E and W in Table 4.1.1 and Table 5.2?

Reply: It is the opinion of the Committee that recognized standards for wind and earthquake may be used in lieu of ASCE/SEI 7, provided the User's Design Specification shall cite the Standard to be applied and specify suitable load factors for E (earthquake) and W (wind), where these design parameters are included in the Design Load Combinations in Table 4.1.2 and Table 5.3, and the Load Case Combinations in Table 5.4 and Table 5.5. This Case number shall be shown on the Manufacturer's Design Data Report.

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Case 2681-1

Use of 9Ni, 8Ni, and 5Ni- $\frac{1}{4}$ Mo Materials in Welded Condition for Class 2 Construction

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the materials listed in Table 6.18 of Section VIII, Division 2 and in Table 1 of this Case be used in welded condition for Section VIII, Division 2, Class 2 construction?

Reply: It is the opinion of the Committee that the materials listed in Table 6.18 of Section VIII, Division 2, Class 2 and in Table 1 of this Case may be used in welded condition for Division 2, Class 2 construction provided the following additional requirements are met:

(a) The filler metals for welding the 9Ni, 8Ni, and 5Ni- $\frac{1}{4}$ Mo materials listed in Table 6.18 and the 9Ni materials listed in Table 1 shall meet the additional requirements in (b) if any of the following are true:

(1) The filler metal has an unspecified yield strength.

(2) The specified minimum yield or ultimate tensile strength of the filler metal is below the specified minimums for the base metal.

(3) The welding procedure qualification test shows that the deposited weld metal tensile test strength is lower than the specified minimum ultimate tensile strength of the base metal.

(b) When any of the conditions of (a) are true, the following additional requirements shall apply and shall be met in the procedure qualification tests:

(1) All weld-metal tension test specimen that conform to the dimensional standards of SFA-5.11, para. 12.1, shall be tested to determine the minimum tensile strength and yield strength.

(2) The weld metals for welding the 8Ni and the 9Ni materials listed in Table 6.18 of Section VIII, Division 2 and the 9Ni materials in Table 1 shall meet 690 MPa (100 ksi) minimum tensile strength and 430 MPa (62.5 ksi) minimum yield strength.

(3) The weld metals for welding the 5Ni- $\frac{1}{4}$ Mo steel SA-645, Gr. A material listed in Table 6.18 shall meet 655 MPa (95 ksi) minimum tensile strength and 405 MPa (59 ksi) minimum yield strength. These weld metals may also be used for welding the 8Ni and 9Ni materials listed in Table 6.18 of Section VIII, Division 2 and the 9Ni materials in Table 1 of this Case when the allowable design stresses in Section II, Part D, Table 5A do not exceed those for ultimate tensile strength of 655 MPa (95 ksi) (see Table 5A, Note W4).

(c) The materials listed in Table 1 are exempt from production impact tests of the weld metal in accordance with para. 6.6.5.2(b) of Section VIII, Division 2, Class 2.

(d) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Materials

Specification	UNS	P-No./Group No.
SA-333, Grade 8	K81340	11A/1
SA-334, Grade 8	K81340	11A/1
SA-420, Grade WPL8	K81340	11A/1

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Case 2682

Alternative Procedure for Calculating Allowable Axial Compressive Stress and External Pressure in Cylindrical Shells Constructed of Stainless Steel Alloy 253MA (UNS S30815) at Temperatures Greater Than 1200°F (650°C) and Less Than or Equal to 1650°F (900°C)

Section VIII, Division 1

Approval Date: July 13, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may cylindrical shells constructed of stainless steel alloy 253MA (UNS S30815) be designed for axial compression and external pressure for design temperatures greater than 1200°F (650°C) and less than or equal to 1650°F (900°C)?

Reply: It is the opinion of the Committee that cylindrical shells constructed of stainless steel alloy 253MA (UNS S30815) may be designed for axial compression and external pressure for design temperatures greater than 1200°F (650°C) and less than or equal to 1650°F (900°C), provided the following requirements are met.

1 AXIAL COMPRESSION

The maximum allowable longitudinal compressive stress shall be the smaller of the following values:

- (a) the maximum allowable tensile stress value permitted for the material at the design temperature
- (b) the value of the factor, B , determined by the following procedure where

$$K_1 = \frac{5}{5 - 0.304 \ln(T)}$$

R_o = outside radius of cylindrical shell or tube

t = minimum required thickness of the cylindrical shell or tube

$\ln(T)$ = natural log of the number of operating hours. The minimum value of T (for hot tensile) is equal to 1.0 hr, and the maximum value is equal to 200,000 hr.

Step 1. Using the selected values of t and R_o , calculate the value of factor A using the following formula:

$$A = \frac{0.125}{(R_o/t)} K_1$$

Step 2. Using the value of A calculated in Step 1, enter external pressure chart, [Figure 1](#) or [Figure 1M](#) (see also [Tables 1](#) and [1M](#)). Move vertically to an intersection with the material/time line. Interpolation may be made between lines for intermediate times. If tabular values are used, interpolation may be used to determine a B value that lies between two adjacent tabular values for a specific number of hours. Such interpolation may also be used to determine a B value at an intermediate number of hours that lies between two sets of tabular values, after first determining B values for each set of tabular values.

In cases where the value at A falls to the right of the end of the material/time line, assume an intersection with the horizontal projection of the upper end of the material/time line. If tabular values are used, the maximum tabulated value shall be used. The minimum value of A to be used is 0.00001.

Step 3. From the intersection obtained in Step 2, move horizontally and read the value of factor B . This is the maximum allowable compressive stress for the values of t and R_o used in Step 1.

Step 4. Compare the value of B determined in Step 3 with the computed longitudinal compressive stress using the selected values of t and R_o . If the value of B is smaller than the computed compressive stress, a greater value of t must be selected and the procedure repeated until a value of B is obtained that is greater than the compressive stress computed.

2 EXTERNAL PRESSURE

The maximum allowable external pressure shall be the smaller of the following values:

(a) the maximum allowable tensile stress value permitted for the material at the design temperature

(b) the value of the factor B determined by the following procedure

where

$$K_2 = \frac{3}{3 - 0.1303 \ln(T)}$$

D_o = outside diameter of cylindrical shell or tube

L = effective length of shell or tube

t = minimum required thickness of the cylindrical shell or tube

$\ln(T)$ = natural log of the number of operating hours.

The minimum value of T (for hot tensile) is equal to 1.0 hr, and the maximum value is equal to 200,000 hr.

Step 1. Using the selected values of t , L , and D_o , determine the value of factor A from Fig. G of Section II, Part D.

Step 2. Using the value of A calculated in Step 1, enter external pressure chart, [Figure 1](#) or [Figure 1M](#) (see also [Tables 1](#) and [1M](#)). Move vertically to an intersection with the material/time line. Interpolation may be made between lines for intermediate times. If tabular values are used, interpolation may be used to determine a B value that lies between two adjacent tabular values for

a specific number of hours. Such interpolation methods may also be used to determine a B value at an intermediate number of hours that lies between two sets of tabular values, after first determining B values for each set of tabular values.

In cases where the value at A falls to the right of the end of the material/time line, assume an intersection with the horizontal projection of the upper end of the material/time line. If tabular values are used, the maximum tabulated value shall be used. The minimum value of A to be used is 0.00001.

Step 3. From the intersection obtained in Step 2, move horizontally and read the value of factor B . If tabulated values are used, determine B as in Step 2 and apply it to the equation in Step 4.

Step 4. Calculate the value of allowable external pressure from the following equation:

$$P_a = \frac{4BK_2}{3(D_o/t)}$$

Step 5. Compare the value of P_a determined above with the specified design external pressure. If the value of P_a is smaller than the design external pressure, a greater value of t must be selected and the procedure repeated until a value of P_a is obtained that is greater than the specified external pressure for the cylindrical shell or tube.

Figure 1
External Pressure Chart for Stainless Steel Alloy UNS S30815 At 1650°F

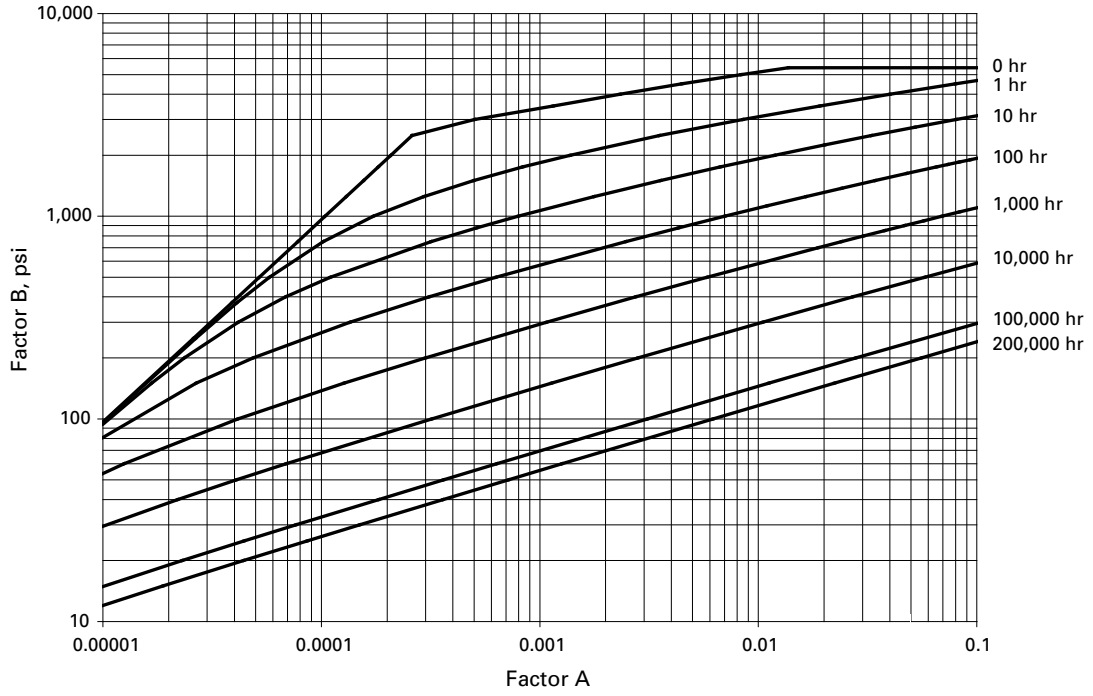


Table 1
Tabular Values at 1650°F For Figure 1

Time, hr	A	B, psi	Time, hr	A	B, psi	Time, hr	A	B, psi			
0	1.00E -05	96.5	10	5.12E -04	875	1000	3.79E -02	850			
	2.60E -05	250		7.96E -04	1000		4.68E -02	900			
	3.90E -05	375		1.77E -03	1250		5.72E -02	950			
	5.20E -05	500		3.57E -03	1500		6.93E -02	1000			
	7.80E -05	750		6.71E -03	1750		8.34E -02	1050			
	1.04E -04	1000		1.19E -02	2000		1.00E -01	1100			
	1.30E -04	1250		2.01E -02	2250		10,000	1.00E -05	29.5		
	1.56E -04	1500		3.29E -02	2500			2.20E -05	40		
	1.82E -04	1750		5.21E -02	2750			4.08E -05	50		
	2.08E -04	2000		8.06E -02	3000			6.90E -05	60		
	2.60E -04	2500		1.00E -01	3130			3.20E -04	100		
	5.04E -04	3000		100	1.00E -05			81	1.13E -03	150	
	1.15E -03	3500			2.67E -05			150	2.81E -03	200	
	2.33E -03	4000			4.87E -05			200	1.05E -02	300	
	4.46E -03	4500			1.35E -04			300	2.71E -02	400	
	8.34E -03	5000			3.12E -04			400	5.78E -02	500	
	1.37E -02	5400			6.29E -04			500	1.00E -01	586	
	1.00E -01	5400			2.48E -03			750	100,000	1.00E -05	14.9
	1	1.00E -05			96			4.30E -03		875	2.31E -05
2.66E -05		250	7.03E -03		1000	4.43E -05		25			
4.12E -05		375	1.10E -02		1125	7.64E -05		30			
5.78E -05		500	1.65E -02		1250	1.83E -04		40			
1.02E -04		750	2.41E -02		1375	3.62E -04		50			
1.73E -04		1000	3.43E -02		1500	6.34E -04		60			
2.94E -04		1250	4.78E -02		1625	3.11E -03		100			
4.98E -04		1500	6.54E -02		1750	1.12E -02	150				
8.34E -04		1750	7.38E -02		1800	2.80E -02	200				
1.38E -03		2000	8.31E -02		1850	1.00E -01	296				
3.52E -03		2500	9.33E -02		1900	200,000	1.00E -05	12			
8.52E -03		3000	1.00E -01		1930		1.89E -05	15			
1.91E -02		3500	1000	1.00E -05	53.7		4.40E -05	20			
4.01E -02		4000		1.25E -05	60		8.61E -05	25			
7.98E -02		4500		4.14E -05	100		1.50E -04	30			
1.00E -01		4670		1.27E -04	150		3.61E -04	40			
10		1.00E -05		94	3.00E -04		200	7.18E -04		50	
		1.67E -05		150	1.07E -03		300	1.26E -03		60	
		2.36E -05		200	2.75E -03		400	6.21E -03	100		
	4.16E -05	300		5.83E -03	500		2.23E -02	150			
	6.87E -05	400		1.88E -02	700		5.59E -02	200			
	1.10E -04	500		2.40E -02	750		1.00E -01	240			
	3.18E -04	750		3.04E -02	800						

Figure 1M
External Pressure Chart for Stainless Steel Alloy UNS S30815 At 900°C

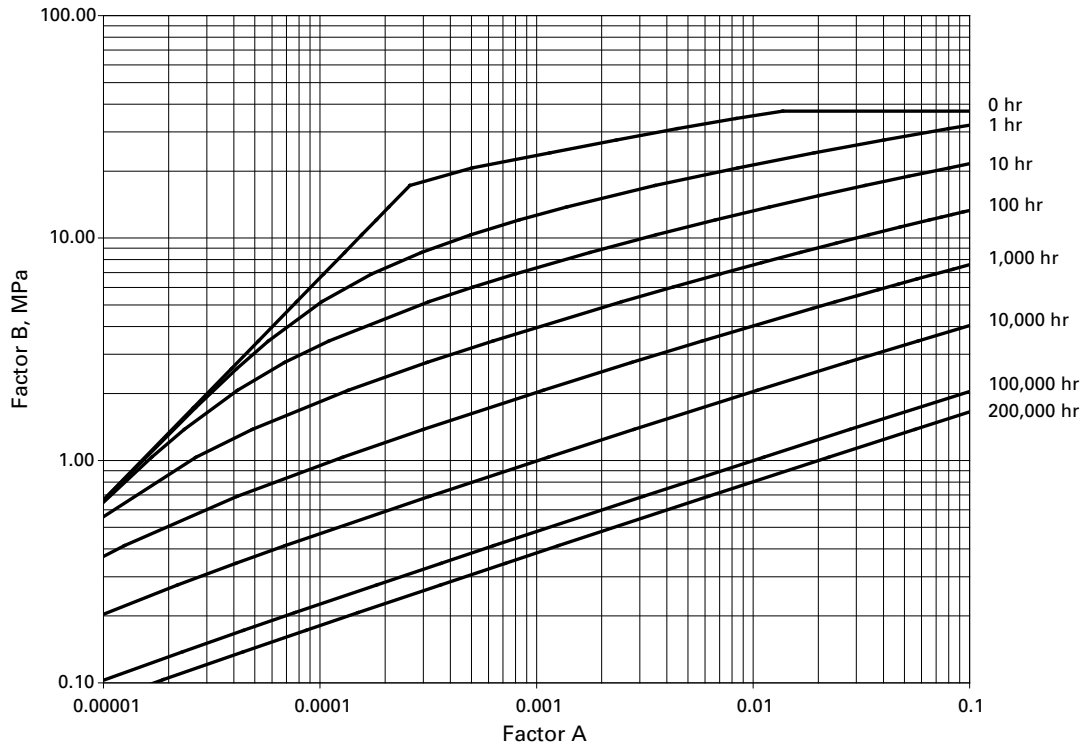


Table 1M
Tabular Values at 900°C For Figure 1M

Time, hr	A	B, MPa	Time, hr	A	B, MPa	Time, hr	A	B, MPa		
0	1.00E -05	0.67	10	5.12E -04	6.03	1000	3.79E -02	5.86		
	2.60E -05	1.72		7.96E -04	6.90		4.68E -02	6.21		
	3.90E -05	2.59		1.77E -03	8.62		5.72E -02	6.55		
	5.20E -05	3.45		3.57E -03	10.34		6.93E -02	6.90		
	7.80E -05	5.17		6.71E -03	12.07		8.34E -02	7.24		
	1.04E -04	6.90		1.19E -02	13.79		1.00E -01	7.58		
	1.30E -04	8.62		2.01E -02	15.51					
	1.56E -04	10.34		3.29E -02	17.24		10,000	1.00E -05	0.20	
	1.82E -04	12.07		5.21E -02	18.96			2.20E -05	0.28	
	2.08E -04	13.79		8.06E -02	20.69			4.08E -05	0.34	
	2.60E -04	17.24		1.00E -01	21.58			6.90E -05	0.41	
	5.04E -04	20.69						3.20E -04	0.69	
	1.15E -03	24.13		100	1.00E -05			0.56	1.13E -03	1.03
	2.33E -03	27.58			2.67E -05			1.03	2.81E -03	1.38
	4.46E -03	31.03			4.87E -05			1.38	1.05E -02	2.07
	8.34E -03	34.48			1.35E -04			2.07	2.71E -02	2.76
	1.37E -02	37.23			3.12E -04			2.76	5.78E -02	3.45
1.00E -01	37.23	6.29E -04	3.45		1.00E -01	4.04				
		2.48E -03	5.17							
1	1.00E -05	0.66	4.30E -03		6.03	100,000		1.00E -05	0.10	
	2.66E -05	1.72	7.03E -03		6.90			2.31E -05	0.14	
	4.12E -05	2.59	1.10E -02		7.76			4.43E -05	0.17	
	5.78E -05	3.45	1.65E -02		8.62			7.64E -05	0.21	
	1.02E -04	5.17	2.41E -02		9.48			1.83E -04	0.28	
	1.73E -04	6.90	3.43E -02		10.34		3.62E -04	0.34		
	2.94E -04	8.62	4.78E -02		11.20		6.34E -04	0.41		
	4.98E -04	10.34	6.54E -02		12.07		3.11E -03	0.69		
	8.34E -04	12.07	7.38E -02		12.41		1.12E -02	1.03		
	1.38E -03	13.79	8.31E -02		12.76		2.80E -02	1.38		
	3.52E -03	17.24	9.33E -02	13.10	1.00E -01		2.04			
	8.52E -03	20.69	1.00E -01	13.31						
	1.91E -02	24.13	1000	1.00E -05	0.37		200,000	1.00E -05	0.08	
	4.01E -02	27.58		1.25E -05	0.41			1.89E -05	0.10	
	7.98E -02	31.03		4.14E -05	0.69			4.40E -05	0.14	
	1.00E -01	32.20		1.27E -04	1.03			8.61E -05	0.17	
				3.00E -04	1.38			1.50E -04	0.21	
10	1.00E -05	0.65		1.07E -03	2.07	3.61E -04		0.28		
	1.67E -05	1.03		2.75E -03	2.76	7.18E -04		0.34		
	2.36E -05	1.38		5.83E -03	3.45	1.26E -03		0.41		
	4.16E -05	2.07		1.88E -02	4.83	6.21E -03		0.69		
	6.87E -05	2.76		2.40E -02	5.17	2.23E -02		1.03		
	1.10E -04	3.45		3.04E -02	5.52	5.59E -02		1.38		
	3.18E -04	5.17				1.00E -01		1.65		

Case 2683

Use of Method A as the Only Design Basis for Class II Vessels

Section X

Approval Date: July 13, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In lieu of the requirements in RD-1120(a), under what conditions may a Class II vessel use only Method A design rules given in RD-1170?

Reply: It is the opinion of the Committee that Method A as defined in RD-1170 may be used for Class II vessels provided:

(a) The vessel inside diameter shall not exceed 48 in. (1200 mm).

(b) The internal design pressure shall not exceed 250 psi (1.72 MPa).

(c) All other requirements of Section X shall apply.

(d) This Case Number shall be shown on the Fabricator's Design Report.

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Case 2684-5

47Ni-23Cr-23Fe-7W, UNS N06674, Alloy Seamless Pipe and Tube, and Forgings

Section I; Section VIII, Division 1

Approval Date: August 1, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed 47Ni-23Cr-23Fe-7W, UNS N06674, alloy seamless pipe and tube, and forgings conforming to the specifications listed in [Table 1](#), be used for welded construction under the rules of Section I and Section VIII, Division 1?

Reply: It is the opinion of the Committee that solution annealed 47Ni-23Cr-23Fe-7W, UNS N06674, alloy seamless pipe and tube, and forgings, conforming to the specifications listed in [Table 1](#), may be used for welded construction under the rules of Section I and Section VIII, Division 1, provided the following additional requirements are met:

(a) For Section I, the y values (see Section I, PG-27.4.6) shall be as follows:

- (1) 1,050°F (565°C) and below: 0.4
- (2) 1,100°F (595°C): 0.5
- (3) 1,150°F (620°C) and above: 0.7

(b) For Section I, the requirements for post-forming heat treatments after cold-work shall be as required by PG-19. Post-forming heat treatment shall be required for design temperatures exceeding 1,050°F (565°C) but lower than 1,200°F (650°C), and forming strains exceeding 15%, and for design temperatures exceeding 1,200°F (650°C) and forming strains exceeding 10%. The General Note and Notes (1) and (2) of Table PG-19 shall apply. Heat treatment after cold-working shall be solution annealing by heating to a minimum temperature of 2,150°F (1 175°C) followed by quenching in water or rapid cooling by other means.

(c) For Section VIII, Division 1, the rules in Subsection C that apply are those in Part UNF for nickel, cobalt, and high nickel alloys.

(d) For Section VIII, Division 1, the requirements for post-forming heat treatment shall be as required by UNF-79. Post-forming heat treatment shall be required for design temperatures exceeding 1,050°F (565°C) but lower than 1,200°F (650°C) and forming strains exceeding 15%, and for design temperatures exceeding 1,200°F

(650°C) and forming strains exceeding 10%. General Notes (a) and (b) and Note (1) of Table UNF-79 shall apply. Heat treatment after cold-working shall be solution annealing by heating to a minimum temperature of 2,150°F (1 175°C) followed by quenching in water or rapid cooling by other means.

(e) The physical properties for the 47Ni-23Cr-23Fe-7W alloy are as follows:

- (1) mean linear thermal expansion coefficients, as given in [Tables 2](#) and [2M](#)
- (2) thermal conductivity, as given in [Tables 3](#) and [3M](#)
- (3) thermal diffusivity, as given in [Tables 4](#) and [4M](#)
- (4) density: 0.306 lb/in.³ (8 460 kg/m³)
- (5) modulus of elasticity, as given in [Tables 5](#) and [5M](#)
- (6) Poisson's ratio: 0.26

(f) The yield strength and tensile strength values for use in design shall be as given in [Tables 6](#) and [6M](#).

(g) The maximum allowable stress values for the material shall be as given in [Tables 7](#) and [7M](#). The maximum design temperature shall be 1,472°F (800°C).

(h) Separate welding procedure qualifications in accordance with Section IX shall be required for this material. This material may be considered P-No. 45 for the purpose of performance qualifications. Procedure and performance qualifications qualified under previous versions of this Case do not require requalification.

(i) Except for dissimilar weld that is welded to a creep strength enhanced ferritic (CSEF) steel, heat treatment after welding is neither required nor prohibited, but if performed, heat treatment shall consist of heating to a minimum temperature of 1,615°F (880°C) followed by rapid cooling or air cooling.

Postweld heat treatment for welds joining this material to CSEF steels shall follow the heat treatment requirements specified for the applicable CSEF steel.

(j) The charts for determining thickness for those components under external pressure are shown in [Figures 1](#) and [1M](#), and the corresponding tabular values are shown in [Table 8](#).

(k) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

**Table 1
Specifications**

Product Form	ASTM Designation
Forgings	B564-11
Seamless pipe and tube	B167-11

**Table 2
Mean Linear Thermal Expansion Coefficients**

Temperature Range, °F	Coefficient (in./in./°F)
RT - 100	7.3×10^{-6}
RT - 200	7.5×10^{-6}
RT - 300	7.7×10^{-6}
RT - 400	7.9×10^{-6}
RT - 500	8.0×10^{-6}
RT - 600	8.1×10^{-6}
RT - 700	8.2×10^{-6}
RT - 800	8.3×10^{-6}
RT - 900	8.4×10^{-6}
RT - 1,000	8.4×10^{-6}
RT - 1,100	8.4×10^{-6}
RT - 1,200	8.5×10^{-6}
RT - 1,300	8.8×10^{-6}
RT - 1,400	8.9×10^{-6}
RT - 1,500	9.0×10^{-6}
RT - 1,600	9.1×10^{-6}
RT - 1,700	9.2×10^{-6}
RT - 1,800	9.3×10^{-6}

**Table 2M
Mean Linear Thermal Expansion Coefficients**

Temperature Range, °C	Coefficient (mm/mm/°C)
RT - 100	13.6×10^{-6}
RT - 200	14.2×10^{-6}
RT - 300	14.5×10^{-6}
RT - 400	14.9×10^{-6}
RT - 500	15.1×10^{-6}
RT - 600	15.2×10^{-6}
RT - 700	15.8×10^{-6}
RT - 800	16.2×10^{-6}
RT - 900	16.4×10^{-6}
RT - 1000	16.8×10^{-6}

**Table 3
Thermal Conductivity**

Temperature, °F	Btu/hr-ft-°F
RT	6.2
100	6.5
200	7.2
300	8.0
400	8.8
500	9.5
600	10.3
700	11.0
800	12.0
900	13.2
1,000	14.0
1,100	14.9
1,200	16.5
1,300	18.1
1,400	19.0
1,500	19.3
1,600	19.3
1,700	19.4
1,800	19.7

**Table 3M
Thermal Conductivity**

Temperature, °C	W/m°C
RT	10.8
100	12.7
200	15.1
300	17.4
400	19.9
500	23.4
600	26.1
700	31.2
800	33.3
900	33.5
1000	34.3

Table 4
Thermal Diffusivity

Temperature, °F	ft ² /hr
RT	0.112
100	0.114
200	0.120
300	0.126
400	0.133
500	0.140
600	0.147
700	0.154
800	0.161
900	0.167
1,000	0.172
1,100	0.179
1,200	0.185
1,300	0.191
1,400	0.196
1,500	0.201
1,600	0.209
1,700	0.216
1,800	0.220

Table 5
Modulus of Elasticity

Temperature, °F	ksi × 10 ³
RT	27.8
100	27.7
200	27.3
300	26.9
400	26.4
500	25.8
600	25.2
700	24.7
800	24.3
900	23.9
1,000	23.4
1,100	22.7
1,200	22.1
1,300	21.6
1,400	21.1
1,500	20.6
1,600	20.1
1,700	19.6
1,800	18.9

Table 4M
Thermal Diffusivity

Temperature, °C	m ² /sec × 10 ⁻⁶
RT	2.89
100	3.11
200	3.43
300	3.75
400	4.07
500	4.35
600	4.63
700	4.93
800	5.15
900	5.50
1000	5.70

Table 5M
Modulus of Elasticity

Temperature, °C	MPa × 10 ³
RT	192
100	188
200	182
300	175
400	169
500	164
600	156
700	149
800	143
900	137
1000	129

Table 6
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
100	34.1	85.6
150	...	...
200	30.5	85.6
250	...	...
300	29.0	85.3
350	...	...
400	27.9	82.8
450	...	...
500	27.0	81.3
550	...	...
600	26.0	80.5
650	25.5	80.3
700	25.1	80.1
750	24.6	79.9
800	24.1	79.6
850	23.7	79.2
900	23.3	78.7
950	23.0	77.8
1,000	22.7	76.7
1,050	22.5	75.3
1,100	22.4	73.5
1,150	22.3	71.3
1,200	22.2	68.6
1,250	22.2	65.5
1,300	22.1	61.9
1,350	21.9	57.8
1,400	21.6	53.3
1,450	21.0	48.3
1,500	20.0	43.0

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 6M
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
40	235	590
65	218	590
100	209	590
125	204	590
150	200	587
175	196	579
200	193	572
225	190	567
250	187	562
275	184	559
300	181	556
325	178	555
350	175	553
375	172	552
400	169	551
425	167	549
450	164	547
475	161	544
500	159	539
525	157	533
550	156	525
575	155	515
600	154	503
625	154	489
650	153	459
675	153	453
700	152	431
725	151	406
750	150	378
775	147	349
800	142	317

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to "minimum" or "average," as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to "average" as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 7
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi	Stress, ksi
100	22.7	22.7
150	...	22.7 [Note (2)]
200	20.3	22.7 [Note (2)]
250	...	22.7 [Note (2)]
300	19.3	22.7 [Note (2)]
350	...	22.7 [Note (2)]
400	18.6	22.7 [Note (2)]
450	...	22.7 [Note (2)]
500	18.0	22.7 [Note (2)]
550	...	22.7 [Note (2)]
600	17.4	22.7 [Note (2)]
650	17.0	22.7 [Note (2)]
700	16.7	22.6 [Note (2)]
750	16.4	22.1 [Note (2)]
800	16.1	21.7 [Note (2)]
850	15.8	21.3 [Note (2)]
900	15.5	21.0 [Note (2)]
950	15.3	20.7 [Note (2)]
1,000	15.1	20.4 [Note (2)]
1,050	15.0	20.3 [Note (2)]
1,100	14.9	17.2 [Note (1)], [Note (2)]
1,150	14.2 [Note (1)]	14.2 [Note (1)]
1,200	11.8 [Note (1)]	11.8 [Note (1)]
1,250	9.8 [Note (1)]	9.8 [Note (1)]
1,300	8.2 [Note (1)]	8.2 [Note (1)]
1,350	6.9 [Note (1)]	6.9 [Note (1)]
1,400	5.7 [Note (1)]	5.7 [Note (1)]
1,450	4.7 [Note (1)]	4.7 [Note (1)]
1,500	3.7 [Note (1)], [Note (3)]	3.7 [Note (1)], [Note (3)]

NOTES:

- (1) These stress values are obtained from time-dependent properties.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for applications where slight amounts of distortion can cause leakage or malfunction.
- (3) The maximum use temperature for this alloy is 1472°F (800°C); the value listed at 1500°F is provided for interpolation purposes only.

Table 7M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress, MPa	Stress, MPa
40	157	157
65	145	157 [Note (2)]
100	139	157 [Note (2)]
125	136	157 [Note (2)]
150	133	157 [Note (2)]
175	131	157 [Note (2)]
200	129	157 [Note (2)]
225	127	157 [Note (2)]
250	125	157 [Note (2)]
275	123	157 [Note (2)]
300	121	157 [Note (2)]
325	119	157 [Note (2)]
350	117	157 [Note (2)]
375	115	155 [Note (2)]
400	113	152 [Note (2)]
425	111	150 [Note (2)]
450	109	147 [Note (2)]
475	108	145 [Note (2)]
500	106	143 [Note (2)]
525	105	142 [Note (2)]
550	104	140 [Note (2)]
575	103	136 [Note (1)], [Note (2)]
600	103	113 [Note (1)], [Note (2)]
625	95.2 [Note (1)]	95.2 [Note (1)]
650	80.6 [Note (1)]	80.6 [Note (1)]
675	68.6 [Note (1)]	68.6 [Note (1)]
700	58.4 [Note (1)]	58.4 [Note (1)]
725	49.6 [Note (1)]	49.6 [Note (1)]
750	42.0 [Note (1)]	42.0 [Note (1)]
775	35.2 [Note (1)]	35.2 [Note (1)]
800	29.2 [Note (1)], [Note (3)]	29.2 [Note (1)], [Note (3)]

NOTES:

- (1) These stress values are obtained from time-dependent properties.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for applications where slight amounts of distortion can cause leakage or malfunction.
- (3) The maximum use temperature for this alloy is 800°C (1472°F); the value listed at 1500°F is provided for interpolation purposes only.

Table 8
Tabular Values for Figures 1 and 1M

Temperature, °F	A	B, psi	Temperature, °C	A	B, MPa
RT	1.00E-05	139	RT	1.00E-05	1.0
	7.19E-05	1,000		1.04E-04	10.0
	7.29E-04	10,100		7.29E-04	70.0
	1.26E-03	11,400		1.26E-03	80.0
	2.34E-03	12,800		2.34E-03	88.0
	3.85E-03	13,900		3.85E-03	96.0
	1.02E-02	16,000		1.02E-02	110.0
	2.00E-02	17,000		2.00E-02	117.5
	1.00E-01	17,000		1.00E-01	117.5
210	1.00E-05	137	100	1.00E-05	0.9
	7.33E-05	1,000		1.06E-04	10.0
	6.65E-04	9,100		6.65E-04	62.5
	1.31E-03	10,300		1.31E-03	71.0
	2.97E-03	11,800		2.97E-03	81.0
	6.00E-03	13,100		6.00E-03	90.0
	1.12E-02	14,200		1.12E-02	98.0
	2.00E-02	15,200		2.00E-02	104.5
	1.00E-01	15,200		1.00E-01	104.5
570	1.00E-05	127	300	1.00E-05	0.9
	7.87E-05	1,000		1.14E-04	10.0
	6.17E-04	7,800		6.17E-04	54.0
	1.42E-03	9,100		1.42E-03	63.0
	2.52E-03	10,000		2.52E-03	70.0
	5.84E-03	11,300		5.84E-03	78.0
	2.06E-02	13,100		2.06E-02	90.5
	1.00E-01	13,100		1.00E-01	90.5
	930	1.00E-05		119	500	1.00E-05	0.8
8.40E-05		1,000	1.22E-04	10.0	
5.82E-04		7,000	5.82E-04	48.0	
8.05E-04		7,500	8.05E-04	52.0	
1.92E-03		8,600	1.92E-03	59.0	
5.22E-03		9,800	5.22E-03	68.0	
2.45E-02		11,500	2.45E-02	79.5	
1.00E-01		11,500	1.00E-01	79.5	
1,470		1.00E-05	104	800		1.00E-05	0.7
	9.66E-05	1,000	1.40E-04		10.0
	6.29E-04	6,500	6.29E-04		45.0
	1.32E-03	7,300	1.32E-03		50.0
	3.04E-03	8,100	3.04E-03		56.0
	3.16E-02	10,300	3.16E-02		71.0
	1.00E-01	10,300	1.00E-01		71.0

Figure 1
Chart for Determining Shell Thickness of Components under External Pressure Developed
for 47Ni-23Cr-23Fe-7W, UNS N06674

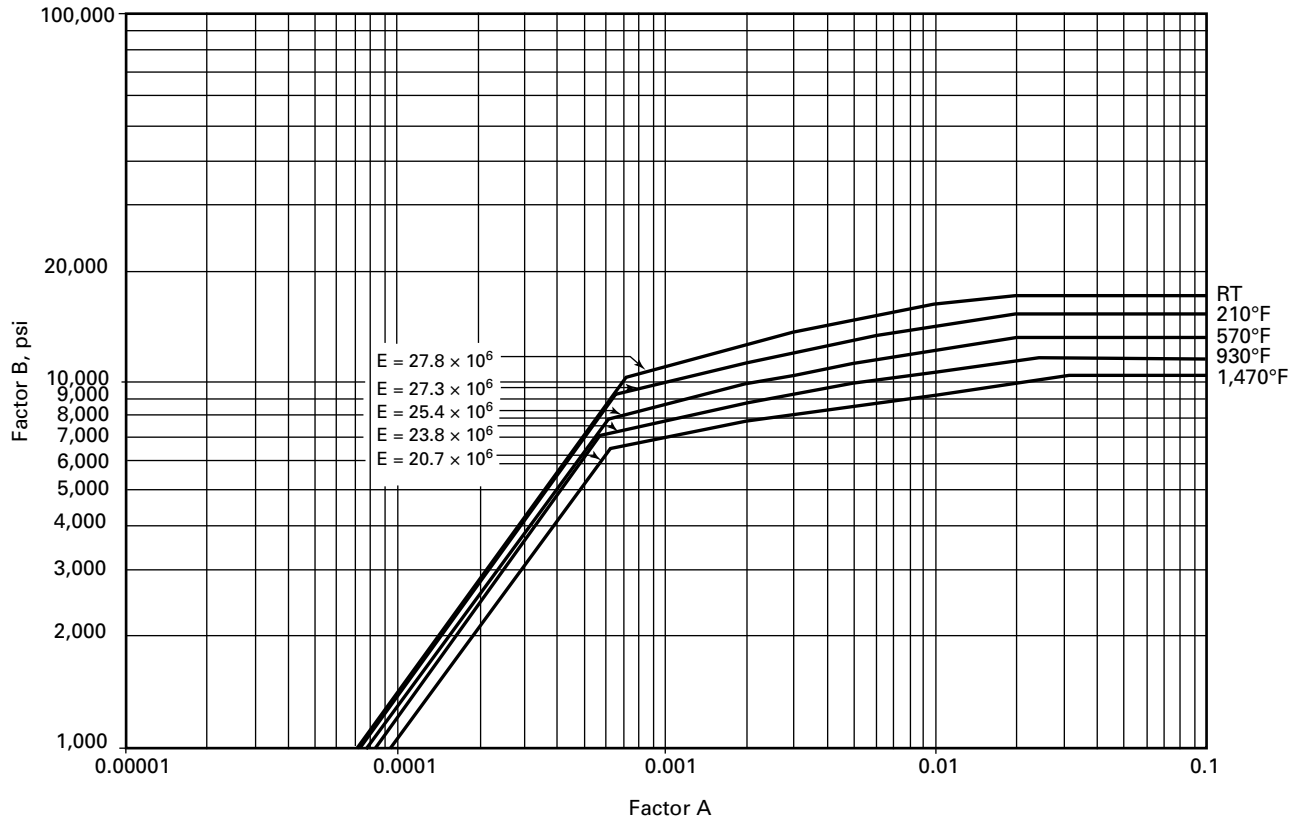
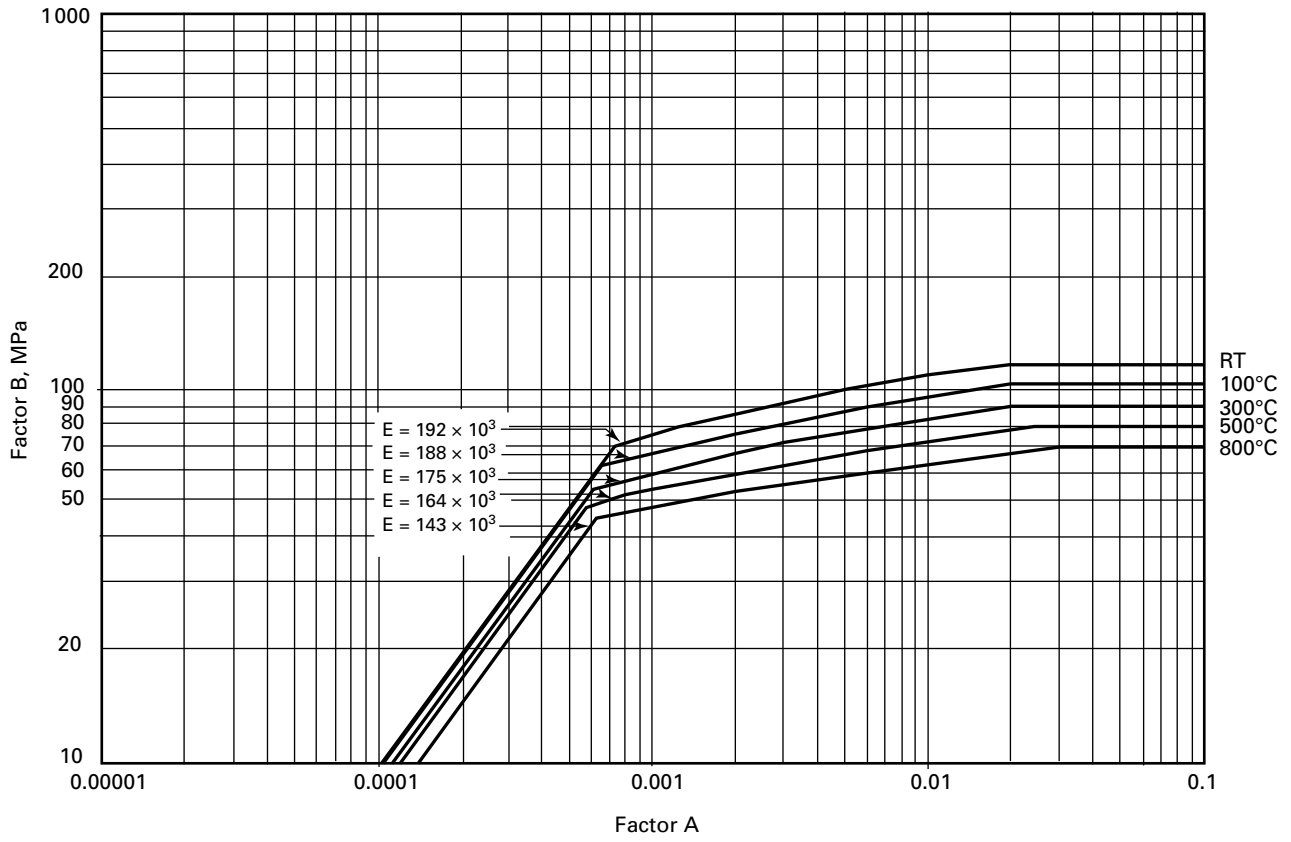


Figure 1M
Chart for Determining Shell Thickness of Components under External Pressure Developed
for 47Ni-23Cr-23Fe-7W, UNS N06674



Case 2686

Use of Appendix 23 for External Pressure Design of Copper and Copper Alloy Condenser and Heat Exchanger Tubes With Integral Fins at Elevated Temperatures

Section VIII, Division 1

Approval Date: August 5, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May copper and copper alloy condenser and heat exchanger tubes with integral fins be used under the rules of Section VIII, Division 1, Appendix 23 at design temperatures exceeding 150°F (65°C)?

Reply: It is the opinion of the Committee that copper and copper alloy condenser and heat exchanger tubes with integral fins may be used under the rules of Section

VIII, Division 1, Appendix 23 at design temperatures exceeding 150°F (65°C), provided the following requirements are met:

(a) The design temperature shall be limited to the maximum temperature listed in Section II, Part D, Table 1B corresponding to the time independent allowable stress, or the maximum temperature shown on the external pressure chart for the corresponding material, whichever is less.

(b) This Case number shall be identified in the Manufacturer's Data Report.

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Case 2687-1

UNS S31635 Tubing

Section IV

Approval Date: December 18, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S31635 austenitic stainless steel in the material specification SA-213/SA-213M Grade TP316Ti be used in the construction of hot water heating boilers?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the welded construction of hot water heating boilers, provided the following requirements are met:

(a) The allowable stress values for the tubing in accordance with SA-213/SA-213M Grade TP316Ti shall be as listed in [Tables 1](#) and [1M](#).

(b) For the purpose of welding procedure and performance qualification this material shall be considered P-No. 8, Group 1.

(c) For external pressure, Fig. HA-2 of Section II, Part D shall be used.

(d) The maximum design temperature shall be 500°F (260°C).

(e) The water temperature shall not exceed 210°F (98°C).

(f) Tubing may utilize the thickness requirements of HF-203.4 at pressures up to 160 psi (1 100 kPa).

(g) All other requirements of Section IV shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values
for SA-213/SA-213M Grade TP316Ti

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	15.0
150	15.0
200	15.0
250	15.0
300	15.0
400	14.3
500	13.2

GENERAL NOTE: This steel may be expected to develop embrittlement after service at moderately elevated temperatures; see Appendix A, A-207 and A-208 of Section II, Part D.

Table 1M
Maximum Allowable Stress Values
for SA-213/SA-213M Grade TP316Ti

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	103
100	103
150	103
200	99.3
225	95.3
250	92.0
275 [Note (1)]	89.3

GENERAL NOTE: This steel may be expected to develop embrittlement after service at moderately elevated temperatures; see Appendix A, A-207 and A-208 of Section II, Part D.

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

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Case 2688

Use of Austenitic Stainless Steel Material With Minimum Thickness of 0.020 in. (0.5 mm) for Hot Water Heating Boilers

Section IV

Approval Date: August 19, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permitted to use stainless steel tubes or pipes with a minimum thickness of 0.020 in. (0.5 mm) and an outside diameter not exceeding 0.913 in. (23.2 mm), attached by brazing to a stainless steel tubesheet for the construction of hot water heating boilers under Section IV?

Reply: It is the opinion of the Committee that stainless steel tubes or pipes with a minimum thickness of 0.020 in. (0.5 mm) and an outside diameter not exceeding 0.913 in. (23.2 mm), attached by brazing to a stainless steel tubesheet may be used in Section IV, Part HF construction of hot water heating boilers, under the following conditions and made of materials as shown in [Table 1](#):

- (a) Maximum Allowable Working Pressure shall not exceed 45 psi (310 kPa).
- (b) External pressure is not permitted.
- (c) The maximum water temperature shall be 210°F (99°C).
- (d) Welding is not permitted.
- (e) All applicable requirements for furnace brazing shall apply as follows:
 - (1) braze filler metal to be used: BNi-1A (SFA-5.8 AWS classification BNi-1A).
 - (2) furnace brazing temperature above annealing temperature of approximately 2160°F (1180°C).
 - (3) brazing time 30 min at above stated temperature.
 - (4) brazed under vacuum conditions, no protective blanket is required.
 - (5) the complete assembly shall be brazed under these conditions.
- (f) All other applicable parts of Section IV shall apply.
- (g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Materials

Product Form	Specification	Grade
Pipe	SA-312	TP304L, TP316L
Tube	SA-213/SA-213M	TP304L
	SA-249	TP316L
Plate	SA-240	304L, 316L

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Case 2690-1

Attaching Nozzles and Fittings to Headers and Vessels

Section IV

Approval Date: October 2, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible to attach nozzles and fittings to headers and vessels constructed to Section IV, Part HLW using single fillet welds that are smaller than those required by HLW-431.5 and Fig. HLW-431.5, sketches (k) and (l)?

Reply: It is the opinion of the Committee that it is permissible to attach nozzles and fittings to headers and vessels constructed to Section IV, Part HLW using single fillet welds that are smaller than those required by HLW-431.5 and Fig. HLW-431.5, sketches (k) and (l) under the following conditions:

(a) The nozzles and fittings shall not exceed NPS 1½ (DN 40).

(b) The vessel wall thickness shall not exceed $\frac{3}{8}$ in. (10 mm).

(c) The fillet weld shall have a minimum throat dimension of $0.7t$ and a minimum leg dimension of $\frac{3}{32}$ in. (2.5 mm).

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Case 2692-1

Allowance to Use Provisions of Section XIII, 7.8(a) as Alternative to Using Steam to Determine Set Pressure for “Pressure Only” Safety Relief Valves During Capacity Certification Testing (25)

Section IV; Section XIII

Approval Date: February 3, 2025

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may set pressure be determined using the requirements of Section XIII, 7.8(a) as an alternative to using the popping point on steam for “pressure only” safety relief valves during capacity certification testing?

Reply: It is the opinion of the Committee that the set pressure definition for a hot water boiler safety relief valve may be determined as provided in Section XIII, 7.8(a). The test medium shall be room temperature water. The set pressure shall be defined as the pressure of room temperature water at the valve inlet when the flow rate through the valve is 40 cc/min. The valve shall demonstrate a pop action when tested by steam as required by Section XIII, 3.2.14 during capacity test per Section XIII, Table 9.7.2-1.

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Case 2693-1

Use of Nickel Alloy UNS N08367 in Construction of Boilers

Section IV

Approval Date: April 4, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May nickel alloy UNS N08367, meeting the requirements of the applicable Section II, Part B specifications, be used in the construction of heating boilers in accordance with the rules of Section IV?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the construction of heating boilers in accordance with the rules of Section IV, under the following conditions:

(a) Material shall conform to one of the specifications listed in [Table 1](#).

(b) The maximum allowable mean temperature is 500°F (260°C).

(c) The maximum allowable stress values for UNS N08367 are listed in [Tables 2](#) and [2M](#) for material with yield and tensile strength of 45 ksi and 95 ksi, and 310 MPa and 655 MPa, respectively, and in [Tables 3](#) and [3M](#) for material with yield and tensile strength of 45 ksi and 100 ksi, and 310 MPa and 690 MPa, respectively.

(d) This material may utilize the minimum thickness exceptions of HF-301.1(c).

(e) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Product Specifications

Fittings	SB-366, SB-462
Forgings	SB-564
Plate, sheet, and strip	SB-688
Rod (bar)	SB-691
Seamless pipe and tube	SB-690
Welded pipe	SB-675
Welded tube	SB-676

Table 2
Maximum Allowable Stress Values for Material with 45 ksi Yield Strength and 95 ksi Tensile Strength

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi (welded)
100	19.0 (16.1)
200	19.0 (16.1)
300	18.0 (15.3)
400	17.2 (14.6)
500	16.7 (14.2)

Table 2M
Maximum Allowable Stress Values for Material with 310 MPa Yield Strength and 655 MPa Tensile Strength

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa (welded)
40	131 (111)
100	131 (111)
150	124 (105)
200	119 (101)
250	115 (98.1)
275	114 (97.1) [Note (1)]

NOTE: (1) The maximum use temperature shall be 260°C. The value at 275°C temperature is provided for interpolation purposes.

Table 3
Maximum Allowable Stress Values for Material with 45 ksi Yield Strength and 100 ksi Tensile Strength

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi (welded)
100	20.0 (17.0)
200	20.0 (17.0)
300	18.9 (16.1)
400	18.1 (15.4)
500	17.5 (14.9)

Table 3M
Maximum Allowable Stress Values for Material with 310 MPa Yield Strength and 690 MPa Tensile Strength

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa (welded)
40	138 (117)
100	138 (117)
150	130 (111)
200	125 (106)
250	122 (103)
275	119 (102) [Note (1)]

NOTE: (1) The maximum use temperature shall be 260°C. The value at 275°C temperature is provided for interpolation purposes.

Case 2694

Use of Magnetically Impelled Arc Butt Welding (MIABW)

Section I

Approval Date: September 26, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may Magnetically Impelled Arc Butt Welding (MIABW) be acceptable for butt welding of boiler tubes for Section I construction?

Reply: It is the opinion of the Committee that Magnetically Impelled Arc Butt Welding (MIABW) may be acceptable for butt welding of boiler tubes for Section I construction, provided the following conditions are met:

(a) *Applicability.* MIABW shall only be used for butt welding boiler tubes of P-No.1, Gr. 1 and 2 tube materials of the same nominal wall thickness, where wall thickness is between 0.16 in. to 0.3 in. (4 mm to 7.6 mm). MIABW shall be conducted using welding equipment containing permanent magnets in a fabrication shop environment.

(b) *Welding Procedure Specification (WPS) Qualification*

(1) The welding procedure shall be qualified by preparing a boiler tube butt weld test coupon, observing and recording the values for the essential variables from [Table 1](#).

(2) The completed test coupon shall be subjected to the mechanical tests required by QW-451.1 of Section IX procedure qualification. The test coupon shall be subdivided as shown in QW-463.1(d). Test specimens shall be prepared as shown in QW-462.1(b) or (c) and tested in accordance with QW-150 for tension testing. Test specimens shall be prepared as shown in QW-462.3(a) and tested in accordance with QW-160 for bend testing. Acceptance criteria shall be in accordance with QW-153.1 for tension testing and QW-163 for bend testing.

(3) At least two of the remaining segments of the test coupon shall have one of their edges smoothed and etched with a suitable etchant (see QW-470), and the etched surface examined using 5× magnification. An acceptable examination shall demonstrate evidence of complete penetration and fusion of the base metal with no open defects.

(4) Test results shall be documented as set forth in QW-201 on a Welding Procedure Specification Qualification Record (PQR) certified by the Manufacturer.

(c) *Operator Performance Qualification*

(1) Welding operators shall be qualified by preparing a weld test coupon following a qualified WPS for MIABW. The applicable Essential Variables — Automatic Welding given in QW-361.1 shall be observed.

(2) Each end of the performance qualification test coupon shall be cut approximately 1 in. (25 mm) from the weld joint after the test specimen welding has been completed, and then cut longitudinally in segments approximately 60 deg apart on one end, for a length of approximately ½ in. (13 mm) beyond the weld joint, producing six approximately equal width segments (see [Figure 1](#)).

(3) The test coupon shall be secured in a vise or other secure fixture. All six segments shall be bent outwards from the center through an angle not less than 90 deg. The bends shall be examined and compared to the acceptance criteria of QW-163 for bend testing. As an alternative, the coupon may be sectioned and bend tested in accordance with QW-160.

(4) Test results shall be documented as set forth in QW-304.1 on a Welding Operator Performance Qualification Record (WPQ) certified by the Manufacturer. Welding operator performance qualifications using MIABW shall only qualify the welding operator for the MIABW process.

(d) *Nondestructive Examination (NDE)*

(1) Prior to performing the nondestructive examination, the internal and external weld upset scarf produced by the MIABW process shall be removed to a height not greater than 0.01 in. (0.25 mm).

(2) UT Examination personnel shall be qualified and certified in accordance with their employer's written practice in compliance with Section V, Article 1, T-120(e) or (f).

(3) The ultrasonic examination shall be performed with a written procedure prepared in accordance with the requirements of Section V, Article 4, Mandatory Appendix VII. Examination results shall be documented as required by Section V, Article 4, VII-492.

(4) All MIABW welds in boiler tubes shall be evaluated for acceptance by ultrasonic examination using an encoded, pulse-echo, phased array S-scan technique in accordance with Section V, Article 4, Mandatory Appendix V. A sixteen-element phased array probe not larger than 30 mm shall be used with a frequency range of 5 MHz to 10 MHz. The reference block shown in [Figure 2](#) shall be

prepared to represent the production weld joint, including weld upset removal of the I.D. and O.D. The reference block shall be used to establish the reference sensitivity level for all individual beams used in the examination.

(5) The time corrected gain (TCG) shall be calibrated so that the hole with the weakest response (i.e., axial or radial) has a corrected response not less than 40% of full screen height.

(6) Indications exceeding the reference level shall be investigated to determine their size, shape, location, and characterization. Flaws exceeding the following acceptance criteria are unacceptable:

(-a) cracks, lack of fusion, or incomplete penetration regardless of length

(-b) other imperfections whose length exceeds 1/4 in. (6 mm)

(e) Report. This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Performance Qualification Test Coupon

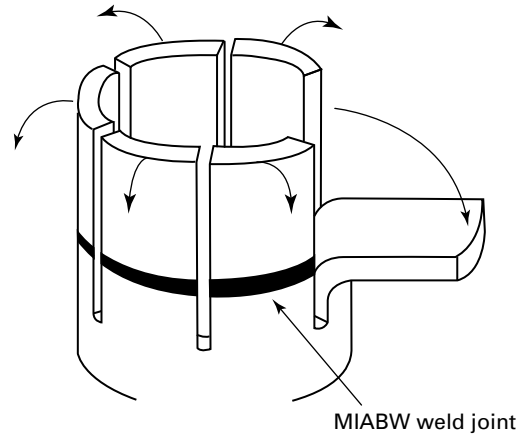
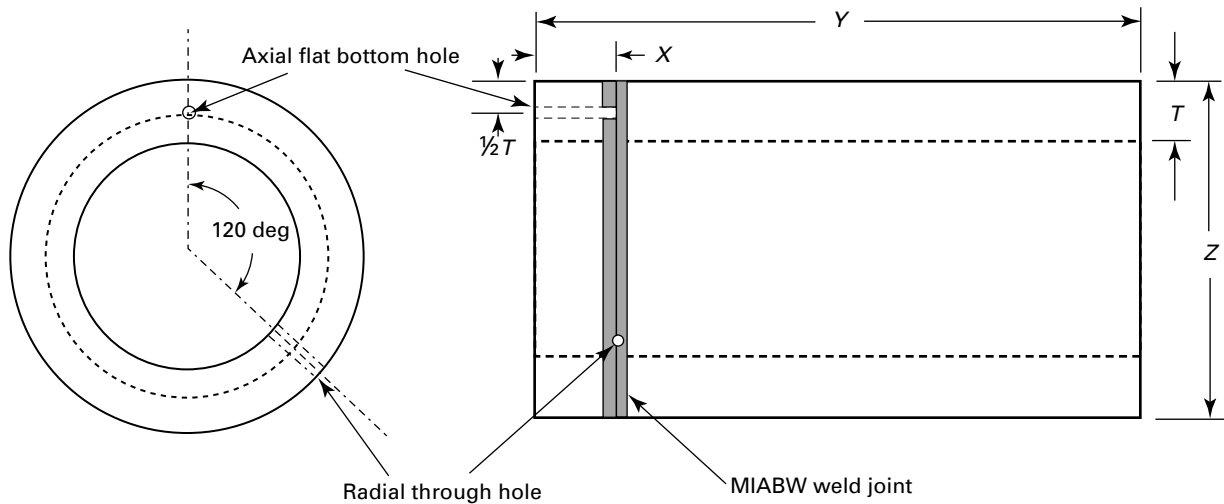


Figure 2
Reference Examination Block



Nominal Dimensions: Hole diameter = 0.040 in. (1 mm) max.

T = between 0.16 in. and 0.3 in. (4 mm and 7 mm)

X = 3/4 in. (19 mm) min.

Y = 6 in. (150 mm) min.

Z = as selected, where $Z \geq 0.9 \times \text{Tube O.D.}$ and $\leq 1.5 \times \text{Tube O.D.}$

Table 1
MIABW Variables

Variable Description	Essential	Nonessential
Change in the Welding Controller Module from that qualified	X	...
Change in welding machinery type, manufacturer, or the machinery components	X	...
Change in welding voltage greater than ± 5 volts from that qualified	X	...
Change in welding amperage greater than ± 50 amps from that qualified	X	...
Increase in tube thickness greater than 10% from that qualified	X	...
Increase in tube diameter greater than 10% from that qualified	X	...
Increase in the distance from tube ends to electrode grips greater than 10% from that qualified	X	...
Change in programmed arc initiation current greater than $\pm 10\%$ from that qualified	X	...
Change in programmed arc stabilization current greater than $\pm 10\%$ from that qualified	X	...
Change in programmed arc rotation current greater than $\pm 10\%$ from that qualified	X	...
Change in programmed cleaning/upset current greater than $\pm 10\%$ from that qualified	X	...
Change in programmed arc initiation time greater than $\pm 10\%$ from that qualified	X	...
Change in programmed arc stabilization time greater than $\pm 10\%$ from that qualified	X	...
Change in programmed arc rotation time greater than $\pm 10\%$ from that qualified	X	...
Change in programmed upset time greater than $\pm 10\%$ from that qualified	X	...
Decrease in clamping pressure from that qualified	X	...
Decrease in upset pressure from that qualified	X	...
Change in shielding gas composition from that qualified	X	...
Change in shielding gas flow rate greater than $\pm 10\%$ from that qualified	X	...
Change in the included angle between the axis of each tube end greater than ± 5 deg	X	...
Change in the condition of heat treatment from "as welded" to PWHT within a specified time and temperature range, and vice versa	X	...
Change in the base metal cleaning method from mechanical cleaning to chemical cleaning, and vice versa	...	X
Change in the type of tube edge preparation from square butt to bevel prep at a specified angle, and vice versa	...	X

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Case 2696

Use of SA-240/SA-240M UNS S41003 Plates in the Construction of Boilers

Section I

Approval Date: July 13, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SA-240/SA-240M UNS S41003 plate be used in Section I construction?

Reply: It is the opinion of the Committee that SA-240/SA-240M UNS S41003 plate may be used for Section I construction, provided the following requirements are met:

(a) The material shall conform to the requirements of SA-240/SA-240M UNS S41003.

(b) For external pressure design, Fig. CS-2 in Section II, Part D shall be used.

(c) For welding procedure and performance qualifications the material shall be classified as P-No. 7, Gr. 1 in accordance with Section IX.

(d) The maximum design temperature shall be 500°F (260°C).

(e) After any thermal cutting, the cut face shall be ground or machined to a bright finish.

(f) Material shall be welded with a filler metal that produces a low carbon content austenitic chromium-nickel weld deposit (e.g., 309L).

(g) For gas metal arc welding processes using a solid wire or metal cored wire, the shielding gas shall have a maximum CO₂ content of 5%.

(h) The heat input during welding shall be controlled between 12.5 kJ/in. and 38 kJ/in. (0.5 kJ/mm and 1.5 kJ/mm).

(i) The interpass temperature shall not exceed 212°F (100°C).

(j) The preheating temperature shall be above 70°F (20°C).

(k) For postweld heat treatment the material shall be treated as P-No. 7, Gr. 1, per the requirements of Table PW-39 except for the following:

(1) Postweld heat treatment is not mandatory when the thickness at the welded joint does not exceed ½ in. (13 mm).

(2) If postweld heat treatment is performed, the minimum holding temperature shall be 1290°F (700°C), and maximum holding temperature shall be 1380°F (750°C).

(l) Maximum allowable stress values shall be as shown in Tables 1 and 1M.

(m) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	18.9
200	18.9
300	18.9
400	18.4
500	17.7

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	130
65	130
100	130
125	130
150	130
200	127
250	123
300 [Note (1)]	119

NOTE: (1) As stated in (d), the maximum use temperature is 500°F (260°C), and the value at 300°C is provided for interpolation only.

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Case 2697-1

Unstayed Flat Head Constructed From Forged Material

Section I

Approval Date: August 1, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible in Section I construction to utilize flat heads with integral flanges constructed from forged material?

Reply: It is the opinion of the Committee that it is permissible to utilize flat heads with integral flanges constructed from forged material attached to cylindrical shells, headers, or pipe as shown in [Figure 1](#). Flat heads of NPS 4 (DN 100) and smaller shall be constructed in accordance with SA-105, SA-181, SA-182, SA-234, SB-366, SB-462, or SA-815 (UNS S31803 only). Flat heads larger than NPS 4 (DN 100) shall meet the following requirements:

(a) The flange may be formed by machining a forged blank or it may be formed by direct forging action.

(b) The flat head

(1) The flat head shall comply with PG-31.

(2) $C = 0.33m$ but not less than 0.20

(3) The flat head thickness shall not be less than the shell thickness.

(4) The corner radius ([Figure 1](#)) on the inside is not less than the following:

$$r = 0.375 \text{ in. (10 mm) for } t_s \leq 1\frac{1}{2} \text{ in. (38 mm)}$$

$$r = 0.25t_s \text{ for } t_s > 1\frac{1}{2} \text{ in. (38 mm) but need not be greater than } \frac{3}{4} \text{ in. (19 mm)}$$

(c) The welding shall meet the requirements for circumferential joints given in Part PW.

(d) The center of the butt weld to the shell shall be located at a distance not less than corner radius, r , as in (b)(4); see [Figure 1](#).

(e) The forged stock shall have a forging reduction ratio not less than 2:1 in the direction radial to the plane of the blank disk and an upset reduction not less than 2:1 in the direction normal to the plane of the blank disk. The forging reduction ratio shall be calculated by dividing the cross-sectional area prior to forging by the cross-sectional area after forging. For upset forging the inverse ratio shall be taken. The forging ratios in each plane may be calculated as the arithmetic sum of the ratios of more than one

forging operation in that plane. The forging operations may be undertaken in any order.

(f) *Tension Test Specimen*

(1) The flange shall have the minimum tensile strength and elongation specified for the material, measured in the direction parallel to the axis of the vessel. Proof of this shall be furnished by a tension test specimen (subsize, if necessary) taken in this direction.

(2) For heads machined from a forged blank, the tensile specimen shall be taken as close to the flange as practical ([Figure 2](#)) and may be located inside or outside the flange.

(3) For heads with flanges formed by direct forging action, the specimen shall be taken from material in the flange or an extension of the flange ([Figure 3](#)).

(4) One test specimen may represent a group of forgings provided they are of the same design, are from the same heat of material, and are forged in the same manner.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Flat Head Dimensions

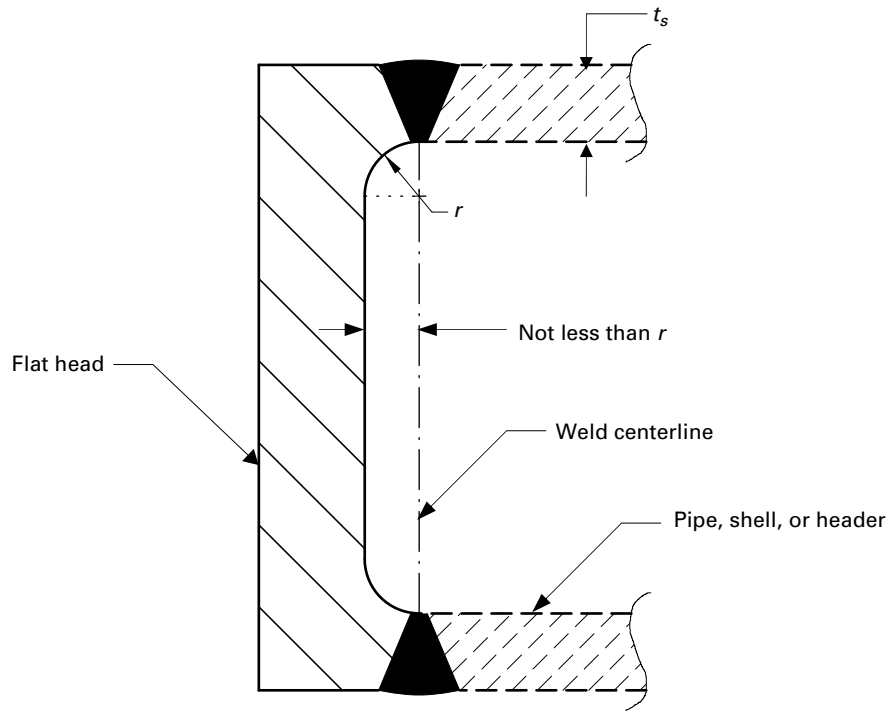


Figure 2
Machined Flat Head Tensile Specimen Location

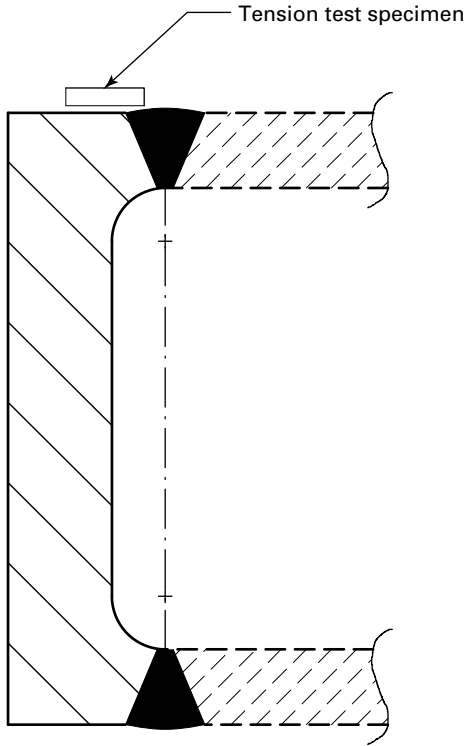
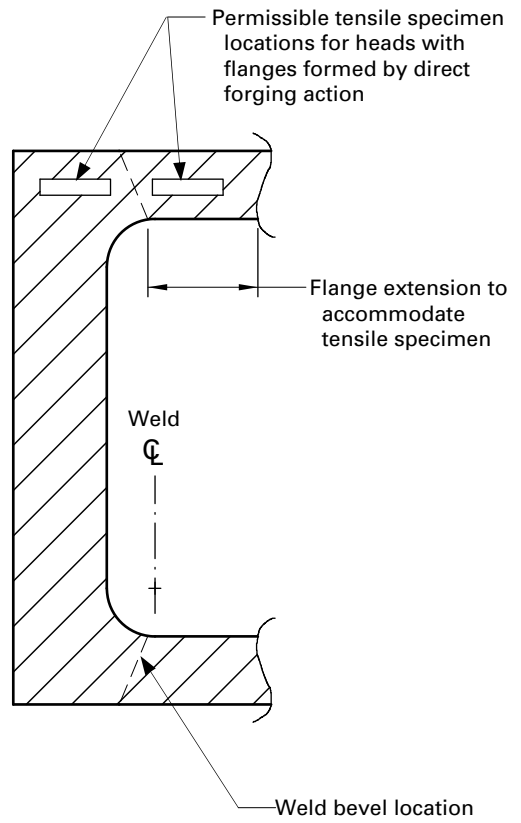


Figure 3
Flat Head with Flange Formed by Direct Forging Action, Tensile Specimen Locations



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Case 2698-2

Use of High Strength Low Alloy Steel Castings

Section VIII, Division 3

Approval Date: April 2, 2020

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what circumstances may high strength low alloy steel castings be allowed for pressure parts under Section VIII, Division 3, including the rules in Article KG-6?

Reply: It is the opinion of the Committee that high strength low alloy steel castings are acceptable for impulsively loaded vessels constructed to Section VIII, Division 3, including the rules in Article KG-6, subject to the following conditions.

1 DESIGN TEMPERATURE RANGE

The vessel shall have a minimum design temperature of 32°F (0°C) and a maximum design temperature of 100°F (38°C).

2 MATERIAL

The steel composition shall be as given in [Table 1](#). The steel shall be degassed to achieve a hydrogen content of less than 3 ppm.

3 CASTING AND HEAT TREATMENT

Material furnished to this Case shall meet the requirements of SA-703/SA-703M except as modified as follows.

(a) Castings shall be made from a single heat and shall not exceed a final mass of 22 U.S. tons (20 000 kg). The maximum final diameter shall be less than 8 ft (2.4 m).

(b) Casting design shall ensure directional solidification of all casting sections back to the feeder heads. Feeder head sizes shall be calculated to ensure complete feeding of the casting during solidification. Machining allowances shall not exceed 1 in. (25 mm) except where this conflicts with these casting design requirements.

(c) The ladle composition shall be confirmed before pouring and the values reported in the Manufacturer's Data Report.

(d) Castings shall be allowed to cool below the transformation range directly after pouring and solidification, before they are reheated for normalizing.

(e) All castings shall receive heat treatment consisting of normalizing, austenitizing, double-liquid quenching, followed by tempering. After annealing and before other treatment, the casting may be hot isostatically pressed at 14.5 ksi \pm 0.3 ksi (1 000 bar \pm 20 bar) and 2,085°F \pm 18°F (1 140°C \pm 10°C). Castings shall be tempered at a minimum temperature of 1,100°F (590°C) followed by liquid cooling. Strong agitation may be required during cooling.

(f) *Temperature Control.* Furnace temperature for heat treating shall be controlled by the use of pyrometers, and the recorded temperature during heat treatment shall be included in the Manufacturer's Data Report.

(g) Casting should be cast oversize and machined to final dimensions to remove surface imperfections. The maximum final wall thickness, T , shall not exceed 13 in. (330 mm).

4 PROPERTIES

Material properties given in [Tables 2](#) and [2M](#) shall be reported in the Manufacturer's Data Report. Test coupons to SA-703/SA-703M (including supplementary requirement S26) cast with the vessel shall have tensile and impact properties at a depth $T/4$ of at least those in [Tables 2](#) and [2M](#). In addition, fracture toughness, K_{JIC} determined according to ASTM E1820 at $T/4$ and at 32°F (0°C) shall exceed 137 ksi in.^{0.5} (150 MPa m^{0.5}). The validity requirement on crack extension (ASTM E1820, para. 9.1.5.1) may be waived.

The prolongations shall be taken from the feeder head end. If the casting is over 78 in. (2 m) length, tensile and impact values shall be obtained from both ends of the casting. Physical properties of the steel are given in [Table 3](#).

Fatigue crack growth may be calculated using the methods of KD-430 but the constants C and m in Tables KD-430 and KD-430M may be replaced by the values given in [Table 4](#).

5 EXAMINATION OF CASTINGS

Nondestructive examination shall be conducted in accordance with the examination methods of Section V except as modified by the following requirements.

Castings shall be examined by the ultrasonic method in accordance with 5.1, except configurations that do not yield meaningful examination results by ultrasonic methods shall be examined by radiographic methods in accordance with Article 2 of Section V using acceptance standards of KE-332. In addition, all external surfaces shall be examined by the magnetic particle method or liquid penetrant method, see 5.2.

Acceptance examination shall be performed after hydrotest.

5.1 ULTRASONIC EXAMINATION

(a) *Examination Procedure.* All castings shall be examined on all external surfaces and all accessible internal surfaces in accordance with SA-609/SA-609M as shown in Article 23 of Section V, both by the straight beam technique and the angle beam technique. The angle beam examination shall be in two circumferential directions and two axial directions.

(b) *Acceptance Standards.* The casting wall thickness shall be divided into thirds: Zone A covers the thirds adjacent to the external and internal surfaces, and Zone B covers the central third.

(1) *Straight Beam Rule.* A casting shall be unacceptable if the results of straight beam examinations show one or more reflectors of measurable length that produces indications accompanied by a complete loss of back wall reflection not associated with or attributable to geometric configurations. Complete loss of back reflection is assumed when the back reflection falls below 5% of full calibration screen height.

A casting shall also be unacceptable if the results of the straight beam examinations show one or more reflectors that either

(-a) produces a 75% or greater loss of back wall reflection that has been determined to be caused by a discontinuity, or

(-b) shows a response equal to or greater than the dynamic amplitude correction curve over an area specified by quality level 1 in Zone A and quality level 2 in Zone B where the quality levels are as defined in Table 2 of SA-609/SA-609M.

(2) *Angle Beam Rule.* A casting shall be unacceptable if the results of angle beam examinations show one or more reflectors that produces indications exceeding in amplitude the indication from the appropriate calibration notches over an area specified by quality level 1 in Zone A and quality level 2 in Zone B, where the quality levels are as defined in Table 2 of SA-609/SA-609M.

More stringent acceptance criteria may be specified in the User's Design Specification.

5.2 MAGNETIC PARTICLE AND LIQUID PENETRANT EXAMINATION

Surface examination shall be performed using a wet magnetic particle method or a liquid penetrant examination. It shall be demonstrated that inspections performed are capable of finding relevant surface defects defined as follows:

(a) *Evaluation of Indications.* Alternating current methods are prohibited. When utilizing magnetic particle examination, mechanical discontinuities at or near the surface will be indicated by the retention of the examination medium. However, all indications are not necessarily imperfections, since certain metallurgical discontinuities may produce similar indications that are not relevant to the detection of unacceptable discontinuities.

Linear indications are indications in which the length is more than three times the width. Rounded indications are indications that are circular or elliptical with length less than three times the width.

(b) *Acceptance Standards*

(1) Only indications with major dimensions greater than $\frac{1}{16}$ in. (1.6 mm) shall be considered relevant.

(2) The relevant indications given in (-a) through (-d) are unacceptable. More stringent acceptance criteria may be specified in the User's Design Specification.

(-a) any linear indications greater than $\frac{1}{16}$ in. (1.6 mm) long for material less than $\frac{5}{8}$ in. (16 mm) thick, greater than $\frac{1}{8}$ in. (3.2 mm) long for material from $\frac{5}{8}$ in. (16 mm) thick to under 2 in. (50 mm) thick, and $\frac{3}{16}$ in. (4.8 mm) long for material 2 in. (50 mm) thick or greater

(-b) rounded indications with dimensions greater than $\frac{1}{8}$ in. (3.2 mm) for thicknesses less than $\frac{5}{8}$ in. (16 mm) and greater than $\frac{3}{16}$ in. (4.8 mm) for thicknesses $\frac{5}{8}$ in. (16 mm) or greater

(-c) four or more rounded indications in a line separated by $\frac{1}{16}$ in. (1.6 mm) or less, edge to edge

(-d) ten or more rounded indications in any 6 in.² (3 900 mm²) of area whose major dimension is no more than 6 in. (150 mm), with the dimensions taken in the most unfavorable location relative to the indications being evaluated

5.3 QUALIFICATION OF NONDESTRUCTIVE PERSONNEL

Qualification and certification of Nondestructive Personnel shall be as specified by KE-110.

6 REMOVAL OF FLAWS

It will generally be necessary to machine external surfaces to remove surface casting imperfections. Any remaining surface flaws in excess of $\frac{1}{8}$ in. (3 mm) height shall be removed by grinding and blending. Reduction in thickness due to blend grinding is permitted to the

extent given in KE-211. Any greater blend grinding shall be included in the component structural assessment as a change in geometry but such grinding shall not exceed one-quarter of the thickness or extend over a length greater than 4 in. (100 mm). After defect elimination, the area is to be re-examined by the magnetic particle method or the liquid penetrant method in accordance with 5.2 to ensure that the imperfection has been removed or reduced to an acceptable size.

7 WELDING AND WELD REPAIRS

No weld repairs are allowed. No welding of component parts or to other components is allowed.

8 ADDITIONAL REQUIREMENTS

In accordance with KM-101, the Materials Manufacturer shall certify that all requirements of the applicable materials specifications in Section II, such as SA-703/SA-703M, all special requirements of Part KM that are to be fulfilled by the Materials Manufacturer, all supplementary material requirements specified by the User's Design Specification (KG-311), and all requirements specified in this Case have been complied with.

9 REPORT

Use of this material shall be specified in the User's Design Specification. This Case number shall be listed on the Manufacturer's Data Report and vessel nameplate.

Table 1
Steel Composition

Element	Composition, %
Carbon	0.15–0.20
Silicon	0.20–0.50
Manganese	0.55–0.70
Phosphorus, max.	0.010
Sulfur, max.	0.005
Chromium	1.35–1.60
Molybdenum	0.35–0.60
Nickel	3.00–3.80
Aluminum	0.015–0.040
Vanadium, max.	0.03
Titanium, max.	0.02
Copper, max.	0.20
Arsenic, max.	0.020
Antimony, max.	0.005
Lead, max.	0.005
Nitrogen, max.	0.010
Tin, max.	0.015
Boron, max.	0.001

Table 2
Minimum Tensile and Impact Properties Required

Thickness When Heat Treated, in.	Minimum Yield Strength, ksi	Minimum Ultimate Tensile Strength, ksi	Minimum Elongation, % [Note (1)]	Minimum Reduction in Area, %	Impact Energy, ft-lb, (Min. of 3) at -100°F	Impact Energy, ft-lb, (Avg. of 3) at -100°F
0 - 6	97	113	15	30	44	48
>6 to <8	94	110	15	30	44	48
8 - 14	91	106	15	30	44	48

NOTE: (1) Gage length = 4 × specimen diameter

Table 2M
Minimum Tensile and Impact Properties Required

Thickness When Heat Treated, mm	Minimum Yield Strength, MPa	Minimum Ultimate Tensile Strength, MPa	Minimum Elongation, % [Note (1)]	Minimum Reduction in Area, %	Impact Energy, J, (Min. of 3) at -73°C	Impact Energy, J, (Avg. of 3) at -73°C
0 - 150	670	780	15	30	60	65
>150 to <200	650	760	15	30	60	65
200 - 360	625	730	15	30	60	65

NOTE: (1) Gage length = 4 × specimen diameter

Table 3
Physical Properties

Density	0.283 lb/in. ³ (7820 kg/m ³)
Modulus of elasticity	29.7 × 10 ³ ksi (205 GPa)

Table 4
Crack Growth Rate Factors

	<i>C</i>	<i>m</i>
U.S. Customary units	2.47 E-9 in./cycle (ksi-in. ^{0.5}) ^{-m}	2.4
SI units	5.0 E-11 m/cycle (MPa m ^{0.5}) ^{-m}	2.4

Case 2701-2

Maximum Dynamic Pressure During Vented Deflagration for Vessels in Low Density Polyethylene Service

Section VIII, Division 3

Approval Date: April 16, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions shall a Section VIII, Division 3 vessel in Low Density Polyethylene (LDPE) Service be designed so that the maximum dynamic pressure during a vented deflagration exceeds 110% of the design pressure permitted by KOP-140?

Reply: It is the opinion of the Committee that the maximum dynamic pressure for vented deflagrations for these vessels may exceed 110% of the design pressure permitted by KOP-140, provided the following conditions are met:

(a) The frequency of deflagrations shall not exceed once every 5 yr. A deflagration is the propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium (see Section VIII, Division 1, Nonmandatory Appendix H).

(b) The maximum dynamic pressure developed in the vented vessel, P_{dyn} does not exceed the pressure determined per the following:

$$P_{dyn} \leq 1.25P_D S_{yO} / S_{yD} \quad (1)$$

$$P_{dyn} \leq P_t \quad (2)$$

where

$$P_{dyn} = P_{static} + (P_{peak} - P_{static})(DLF) \quad (3)$$

P_{dyn} = maximum dynamic pressure in a vented vessel

P_{static} = operating pressure at the time right before the deflagration

P_{peak} = peak pressure developed in a vented vessel

P_t = hydrostatic test pressure as defined in Article KT-3

DLF = Dynamic Load Factor, X_m/X_s

X_m = maximum dynamic deflection in the vessel

X_s = static deflection produced when the peak pressure is applied statically at the same point of maximum dynamic deflection

P_D = vessel design pressure

S_{yO} = material yield strength at the operating temperature immediately before the deflagration. The material yield strengths shall be taken from Section II, Part D, Table Y-1.

S_{yD} = material yield strength at the design temperature

(c) The DLF shall be determined by performing a detailed dynamic structural analysis of the vessel based on the pressure versus time curve of the deflagration event. If no detailed analysis is performed and the deflagration pulse period to vessel structural period ratio is less than or equal to 0.9, a DLF = 1.5 shall be used.

(d) A complete stress analysis shall be performed in accordance with Article KD-2 for the deflagration event including all applicable loading combinations of pressure and temperature.

(e) The fracture mechanics analysis shall consider the load-rate dependent fracture toughness during the deflagration event (see API 579-1/ASME FFS-1).

(f) The calculated number of design cycles shall consider the load frequency, sequence, and magnitude of all loading, including the deflagration loads.

(g) The User shall state in the User's Design Specification that after a deflagration event, an assessment of the vessel (see API 579-1/ASME FFS-1) will be conducted to ensure vessel integrity prior to returning the vessel to service.

(h) This Case number shall be shown on the User's Design Specification and Manufacturer's Data Report as applicable.

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Case 2702-8

Ni-25Cr-20Co Material, UNS N07740

Section I

Approval Date: January 27, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May precipitation-hardenable Ni-25Cr-20Co alloy (UNS N07740) ASTM B983-16 seamless alloy pipe and tube; ASTM B872-19 plate, sheet, and strip; ASTM B1007-17 welded tube; and ASTM B637-18 bars, forgings, and forging stock; and fittings material conforming to the chemical requirements shown in [Table 1](#), the mechanical properties listed in [Table 3](#), and otherwise conforming to the applicable requirements in the specification listed in [Table 4](#) and in this Case be used in welded and nonwelded construction under Section I rules?

Reply: It is the opinion of the Committee that precipitation-hardenable Ni-25Cr-20Co alloy (UNS N07740) ASTM B983-16 seamless alloy pipe and tube; ASTM B872-19 plate, sheet, and strip; ASTM B1007-17 welded tube; and ASTM B637-18 bars, forgings, and forging stock; and fittings material as described in the Inquiry may be used in welded and nonwelded construction complying with the rules of Section I, provided the following additional rules are met:

(a) Material shall be supplied in the solution heat treated and aged condition. ASTM B983-16, ASTM B872-19, ASTM B1007-17, and ASTM B637-18 contain their own heat treatment in their respective table; however, for all other product forms listed in [Table 4](#) of this Case, the solution heat treatment shall be performed at 2,010°F (1100°C) minimum for ½ hr per 1 in. (25 mm) of thickness but not less than 5 min. Material is to be water quenched or rapid air cooled. Aging shall be performed at 1,400°F to 1,500°F (760°C to 816°C) for 4 hr minimum up to 2 in. (50 mm) of thickness, plus an additional ½ hr per additional 1 in. (25 mm) of thickness. Aging shall be followed by air cooling.

(b) As an alternative to the delivery conditions of (a), where the material is to be subjected to additional fabrication operations, the material may be supplied in the solution annealed condition provided:

(1) The marking shall include the suffix “Y” immediately following the Specification number and preceding any other suffix. The “Y” suffix shall not be removed

until the material specification requirements have been completed and the material test report supplemented.

(2) Material supplied in the solution annealed condition shall meet 105 ksi (724 MPa) minimum tensile strength, 60 ksi (414 MPa) minimum yield strength, and 30% elongation in 2 in. (50 mm) or 4D (refers to diameter of the tensile specimen) minimum.

(3) The material supplier shall carry out the full heat treatment requirements of (a) on a sample from the delivery lot to demonstrate compliance with the delivery conditions of this Code Case.

(4) On completion of all fabrication operations, the entire component shall be heat treated in accordance with the requirements of (f) to obtain the mechanical properties in [Table 3](#). Local aging heat treatment is not permitted.

(c) The maximum allowable stress values for the material shall be those given in [Tables 7](#) and [7M](#).

(d) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. Separate welding procedure qualification is required for this material. For performance qualifications, this material shall be considered P-No. 46. Procedure and performance qualifications qualified under previous versions of this Case do not require requalification. Weld procedure qualifications shall be performed with the material in the heat-treated condition planned for production welding, which may be either annealed-aged-welded-postweld heat treated or annealed-welded-postweld heat treated. If welding of both heat treat conditions as shown in (a) and (b) is planned, both qualifications shall be required. The heat treatment condition shall be noted on the PQR and WPS. When welding this alloy to itself, the filler metal shall be SFA-5.14 ERNiCrCo-1 (UNS N07740), and welding shall be limited to the GTAW or GMAW processes. The welding procedure qualification(s) shall be conducted as prescribed in Section IX except that the guided bend test required by QW-160 may use a 4t maximum bend radius.

(e) As an alternative to welding this material with a matching filler metal as noted in (d), SMAW electrodes whose deposit meets the compositional requirements listed in [Table 2](#) may be used. The welding procedure qualification(s) shall be conducted as prescribed in Section IX except that the guided bend test required by QW-160 shall use a 4t maximum bend radius.

(f) Postweld heat treatment for this material is mandatory for all conditions. The postweld heat treatment shall be performed at 1,400°F to 1,500°F (760°C to 815°C) for a minimum of 4 hr for thickness up to 2 in. (50 mm), plus an additional 1 hr per additional 1 in. (25 mm) of thickness and air-cooled.

(g) When a longitudinal weld seam is required in the construction of a component, a weld strength reduction factor as shown in Table 5 shall be applied for welded solution annealed and aged or welded and aged product in accordance with rules in PG-26 for applications at temperatures above 1,112°F (600°C). When using SMAW electrodes meeting the composition listed in Table 2 to make longitudinal seam welds, the weld strength reduction factors (WSRF) shall be as shown in Table 6 for the corresponding temperatures.

(h) Resistance welding may be used to join non-load-bearing attachments to precipitation hardenable Ni-25Cr-20Co alloy (UNS N07740) ASTM B983-16 seamless alloy pipe and tube and ASTM B1007-17 welded tube materials. Postweld heat treatment in accordance with (f) is not mandatory for electric resistance welds used to attach extended heat-absorbing fins to pipe and tube materials, provided the following requirements are met:

(1) The maximum pipe or tube size shall be NPS 4 (DN 100).

(2) The maximum fin thickness or other nonload-bearing attachment shall be 0.125 in. (3 mm).

(3) Prior to using the welding process, the manufacturer shall demonstrate that the heat-affected zone does not encroach upon the minimum wall thickness.

(4) Fins or other nonload-bearing attachments can be of any austenitic stainless steel.

(i) After cold forming to strains in excess of 5%; after any swages, upsets, or flares; or after any hot forming of this material, the component shall be heat treated in accordance with the requirements specified in (a). No local solution annealing may be performed. The entire affected component or part that includes the cold-strained area and transition to unstrained material must be included in both heat treatments. The calculations of cold strains shall be made as described in Section I, PG-19.

(j) The maximum use temperature is 1,472°F (800°C).

(k) S_u and S_y values are listed in Tables 8 and 8M and Tables 9 and 9M, respectively.

(l) *Physical Properties*. See also Tables 10 and 10M, Physical Properties.

(1) density: 0.291 lb/in.³ (8072 kg/m³)

(2) melting range: 2,350°F to 2,484°F (1288°C to 1362°C)

(3) electrical resistivity: 702.7 Ω-circ mil/ft

(m) For Section I, which requires a temperature-dependent parameter, y (see PG-27.4.6), the y values shall be as follows:

(1) 1,150°F (620°C) and below: 0.4

(2) 1,200°F (650°C): 0.5

(3) above 1,200°F (650°C): 0.7

(n) External pressure design is prohibited.

(o) For ASTM B983-16, ASTM B1007-17, ASTM B872-19, and ASTM B637-18 material, this Case number shall appear on the Manufacturer's Data Report.

(p) For product form listed in Table 4, this Case number shall appear in the marking and certification for the material and on the Manufacturer's Data Report. For the postweld heat treatment exemption listed in (h), this Case number shall be shown on the Manufacturer's Data Report or Manufacturer's Partial Data Report for the welded component.

Table 1
Chemical Requirements

Element	Composition Limits, %
Chromium	23.5–25.5
Cobalt	15.0–22.0
Aluminum	0.2–2.0
Titanium	0.5–2.5
Columbium + Tantalum	0.50–2.5
Iron	3.0 max.
Carbon	0.005–0.08
Manganese	1.0 max.
Molybdenum	2.0 max.
Silicon	1.0 max.
Copper	0.50 max.
Phosphorous	0.03 max.
Sulfur	0.03 max.
Boron	0.0006–0.006
Nickel	remainder

Table 2
Chemical Requirements — SMAW Electrode

Element	Wt. %
Carbon	0.04–0.08
Silicon	0.40 max.
Manganese	<0.2
Aluminum	0.6 max.
Cobalt	19.0–21.0
Chromium	19.0–21.0
Iron	<1.0
Molybdenum	5.6–6.1
Titanium	1.9–2.4
Aluminum + Titanium	2.4–2.8
Nickel	Remainder

Table 3
Mechanical Properties Requirements

Tensile strength, min., ksi (MPa)	150 (1035)
Yield strength, min., ksi (MPa)	90 (620)
Elongation in 2 in., min., %	20

Table 4
Specification

Wrought fittings	SB-366
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Table 5
Weld Strength Reduction Factors (WSRF) for Solution Annealed and Aged UNS N07740 Weldments

Temperature, °F	Temperature, °C	Solution Annealed and Aged Weldments, WSRF	Welded Direct Aged Weldments, WSRF
1,100	593	0.9	0.7
1,150	621	0.9	0.7
1,200	649	0.9	0.7
1,250	677	0.9	0.7
1,300	704	0.9	0.7
1,350	732	0.9	0.7
1,400	760	0.9	0.7
1,450	788	0.9	0.7
1,500 [Note (1)]	816 [Note (2)]	0.9	0.7

NOTES:

- (1) The maximum use temperature is 1,472°F. 1,500°F is provided for interpolation only.
 (2) The maximum use temperature is 800°C. 816°C is provided for interpolation only.

Table 6
Weld Strength Reduction Factors for Welds Made With SMAW Electrode Whose Deposit Composition Is Specified in Table 2

Temperature, °F	Temperature, °C	WSRF
1,100	593	0.8
1,150	621	0.8
1,200	649	0.8
1,250	677	0.7
1,300	704	0.7
1,350	732	0.6
1,400	760	0.6
1,450	788	0.5
1,500 [Note (1)]	816 [Note (2)]	0.4

NOTES:

- (1) The maximum use temperature is 1,472° F. 1,500°F is provided for interpolation only.
 (2)) The maximum use temperature is 800°C. 816°C is provided for interpolation only.

Table 7
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress Values, ksi [Note (1)]
-20 to 100	42.9
200	42.9
300	42.9
400	42.6
500	41.1
600	40.3
650	40.1
700	40.0
750	40.0
800	40.0
850	40.0
900	40.0
950	40.0
1,000	40.0
1,050	40.0
1,100	39.8
1,150	39.1
1,200	33.1 [Note (2)]
1,250	26.2 [Note (2)]
1,300	20.2 [Note (2)]
1,350	15.1 [Note (2)]
1,400	10.7 [Note (2)]
1,450	6.9 [Note (2)]
1,500	3.2 [Note (2)], [Note (3)]

NOTES:

- (1) A weld efficiency factor of 0.85 must be applied to welded tubing to ASTM B1007 and welded fittings to SB-366.
- (2) These stress values are obtained from time-dependent properties.
- (3) The maximum use temperature shall be 1,472°F. Datum for 1,500°F temperature is provided for interpolation purposes.

Table 7M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress Values, MPa [Note (1)]
-30 to 40	295
65	295
100	295
150	295
200	294
250	285
300	279
325	277
350	276
375	276
400	276
425	276
450	276
475	276
500	276
525	276
550	276
575	276
600	274
625	269
650	226 [Note (2)]
675	183 [Note (2)]
700	146 [Note (2)]
725	113 [Note (2)]
750	84.1 [Note (2)]
775	59.1 [Note (2)]
800	34.5 [Note (2)]

NOTES:

- (1) A weld efficiency factor of 0.85 must be applied to welded tubing to ASTM B1007 and welded fittings to SB-366.
- (2) These stress values are obtained from time-dependent properties.

Table 8
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °F	S_u Values, ksi [Note (1)]
100	150
200	150
300	150
400	149
500	144
600	141
650	140
700	140
750	140
800	140
850	140
900	140
950	140
1,000	140
1,050	140
1,100	139
1,150	137
1,200	134
1,250	129
1,300	124
1,350	117
1,400	109
1,450	99.1
1,500	88.2 [Note (2)]

NOTES:

- (1) See Section II, Part D, Table U, General Note (b).
 (2) The maximum use temperature shall be 1,472°F. Datum for 1,500°F temperature is provided for interpolation purposes.

Table 8M
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °C	S_u Values, MPa [Note (1)]
40	1034
65	1034
100	1034
150	1034
200	1030
250	998
300	976
325	970
350	967
375	966
400	966
425	966
450	966
475	966
500	966
525	966
550	966
575	966
600	957
625	942
650	921
675	894
700	860
725	819
750	771
775	715
800	651

NOTE: (1) See Section II, Part D, Table U, General Note (b).

Table 9
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °F	S_y Values, ksi [Note (1)]
100	90.0
200	86.5
300	83.8
400	81.2
500	79.1
600	77.6
650	77.2
700	76.8
750	76.7
800	76.7
850	76.7
900	76.7
950	76.7
1,000	76.7
1,050	76.7
1,100	76.7
1,150	76.7
1,200	76.7
1,250	76.7
1,300	76.7
1,350	75.3
1,400	72.7
1,450	69.2
1,500	64.5 [Note (2)]

NOTES:

- (1) See Section II, Part D, Table Y-1, General Note (b).
- (2) The maximum use temperature shall be 1,472°F. Datum for 1,500°F temperature is provided for interpolation purposes.

Table 9M
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °C	S_y Values, MPa [Note (1)]
40	621
65	606
100	594
150	577
200	562
250	548
300	538
325	534
350	531
375	530
400	529
425	529
450	529
475	529
500	529
525	529
550	529
575	529
600	529
625	529
650	529
675	529
700	529
725	522
750	508
775	489
800	463

NOTE: (1) See Section II, Part D, Table Y-1, General Note (b).

Table 10
Physical Properties

Temperature, °F	Modulus of Elasticity, Tension, 10 ³ ksi [Note (1)]	Thermal Conductivity, Btu/ft-hr-°F	Mean CTE, 10 ⁻⁶ in./in./°F [Note (2)]	Specific Heat, Btu/lb-°F
73	31.99	6.1	...	0.108
200	31.58	6.7	6.84	0.112
400	30.85	7.6	7.25	0.117
600	29.83	8.5	7.53	0.119
800	28.68	9.4	7.80	0.120
1,000	27.67	10.4	7.96	0.121
1,200	26.37	11.4	8.24	0.126
1,400	25.08	12.4	8.61	0.133
1,600	23.43	13.5	8.88	0.143
1,800	...	14.6	...	0.152
2,000	...	15.8	...	0.155
2,100	...	16.4	...	0.152

NOTES:

(1) Aged at 1,472°F/4h/AC.

(2) Mean CTE (coefficient of thermal expansion) values are those from 70°F to indicated temperature.

Table 10M
Physical Properties

Temperature, °C	Modulus of Elasticity, Tension, 10 ³ MPa [Note (1)]	Thermal Conductivity, W/(m-°C)	Mean CTE, 10 ⁻⁶ mm/mm/°C [Note (2)]	Specific Heat, J/kg-°C
22	221	10.2	...	449
100	218	11.7	12.38	476
200	212	13.0	13.04	489
300	206	14.5	13.50	496
400	200	15.7	13.93	503
500	193	17.1	14.27	513
600	186	18.4	14.57	519
700	178	20.2	15.03	542
800	169	22.1	15.72	573
900	...	23.8	...	635
1 000	...	25.4	...	656
1 100	...	27.3	...	669

NOTES:

(1) Aged at 800°C/4h/AC.

(2) Mean CTE (coefficient of thermal expansion) values are those from 20°C to indicated temperature.

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Case 2703-1

Instrumented Indentation Testing as Alternative Hardness Test for QW-290 Temper Bead Welding

Section I; Section IX

Approval Date: August 1, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use instrumented indentation testing as an alternative hardness test to that specified in Section IX, QW-290 for temper bead welding?

Reply: It is the opinion of the Committee that instrumented indentation testing may be used as an alternative hardness test to that specified in Section IX, QW-290 for temper bead welding, provided the following requirements are met.

1 SCOPE

(a) Instrumented indentation testing for determination of hardness and other materials parameters covers the requirement for a wide range of macro, micro, and nano indentation testing applications. In this Case, test forces in macro (2 N to 30 kN) range shall be used.

(b) The basic steps and the general requirements of instrumented indentation testing shall be in accordance with ASTM E2546, Standard Practice for Instrumented Indentation Testing.

2 APPARATUS

(a) The Vickers indenter shall be used.

(b) Testing instrument, instrument verification, instrument compliance, and standard reference blocks shall be in accordance with ASTM E2546.

3 PROCEDURE

Step 1. Prepare environment. The test shall be carried out within the temperature range defined by the instrument manufacturer. Generally, it is recommended to perform the test within the temperature range -22°F to 176°F (-30°C to 80°C). The test environment should minimize vibrations or other variations that could adversely affect the performance of the instrument.

Step 2. Select test location. The indentation testing location shall be as specified in QW-290.5.

Step 3. Perform the test. The testing condition shall be as specified in QW-290.5. Force, displacement, and time data shall be continuously and automatically acquired during the test.

Step 4. Analyze results. The hardness is defined by dividing the maximum indentation force by the area of indent. The area of indent is determined in accordance with Appendices X3 and X4 of ASTM E2546.

4 REPORT

(a) The report shall include the information about the instrument, indenter used, temperature, test sample, test location, and the units of the test results.

(b) This Case number shall be recorded on the Procedure Qualification Record.

(c) This Case number shall be shown on the Manufacturer's Data Report.

5 REFERENCE

ASTM E2546-07, Standard Practice for Instrumented Indentation Testing

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Case 2704

Vessel (Production) Impact Tests for Welded Construction of Austenitic Stainless Steels

Section VIII, Division 1

Approval Date: September 26, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the welded construction of austenitic stainless steels be exempted from vessel (production) impact tests?

Reply: It is the opinion of the Committee that the welded construction of austenitic stainless steels may be exempted from vessel (production) impact tests, provided that all of the following requirements are met:

(a) At minimum design metal temperatures (MDMTs) of -155°F (-104°C) and warmer, vessel (production) impact tests are exempted, provided that the impact

test exemption requirements for the applicable Welding Procedure Qualification in UHA-51(e) are satisfied.

(b) At MDMTs colder than -155°F (-104°C) but not colder than -320°F (-196°C), vessel (production) impact tests are exempted, provided the requirements for the pre-use test in UHA-51(f) are satisfied.

(c) At MDMTs colder than -320°F (-196°C), the rules in UHA-51(h)(2) apply.

(d) For autogenous welds (welded without filler metal), the rules in UHA-51(i) apply.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2705

Revised Data Report Forms

Section XII

Approval Date: August 9, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May revised Forms T-1AR, T-2AR, and T-2CR be used in the construction of Section XII transport tanks?

Reply: It is the opinion of the Committee that revised Forms T-1AR, T-2AR, and T-2CR may be used in the construction of Section XII transport tanks, provided the following additional requirements are met.

(a) In the last line of revised Forms T-1AR and T-2AR, the word "Commissions" shall be replaced with the word "Commission."

(b) In the last line of revised Forms T-1AR and T-2AR, the statement "[National Board (incl. endorsement), State, Province, and No.]" Commissions shall be replaced with the statement "(National Board Commission Number and Endorsement)."

(c) In the last line of revised Form T-2CR, the word "Commissions" and the statement "(National Board incl. endorsement, State, Province, and No.)" shall be deleted.

(d) In Table 1, Note (56) that was originally in Table C1 shall be deleted.

(e) In Table 1, Note (57) that was originally in Table C1 shall be changed to Note (56). This new note (56) shall be revised by deleting the words "when the pressure vessel is stamped National Board."

(f) In Table 1, Note (58) that was originally in Table C1 shall be deleted.

(g) This Case number shall be shown on the Manufacturer's Data Report.

FORM T-1AR MANUFACTURER'S DATA REPORT FOR CLASS 1 TRANSPORT TANKS
As Required by the Provisions of the ASME Code Rules, Section XII and Code Case 2705

1. Manufactured and certified by (1)
2. Manufactured for (2)
3. Competent Authority (3)
4. Type (4) (6) (7) (8) (10) (Year built)
5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section XII, Class 1 (11)
6. Shell (18) (19) (20) (21) (22) (23) (24) (25)
7. Seams (21) (22) (23) (24) (25)
8. Heads: (a) Material (15) (25) (29) (b) Material (Spec. No., Grade)

Table with 10 columns: Location (Top, Bottom, Ends), Minimum Thickness, Corrosion Allowance, Crown Radius, Knuckle Radius, Elliptical Ratio, Conical Apex Angle, Hemispherical Radius, Flat Diameter, Side to Pressure (Convex or Concave). Rows (a) and (b).

If removable, bolts used (describe other fastenings) (30)
9. MAWP (31) at max. temp. (32)
Min. design metal temp. (39) at Hydro., pneu., or comb. test pressure (35)

10. Nozzles, inspection and safety valve openings:

Table with 9 columns: Purpose (Inlet, Outlet, Drain), No., Diameter or Size, Type, Material, Nom. Thk., Reinforcement Material, How Attached, Location. Row (37) (38) (38) (18) (42) (43) (44) (46)

11. Supports: Skirt (47) Lugs (No.) Legs (No.) Other (Describe) Attached (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report (34) (36) (48) (49)

(54) CERTIFICATE OF SHOP COMPLIANCE
We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME Code for Transport Tanks, Section XII, T Certificate of Authorization No. (54) expires
Date Co. name (54) (Manufacturer) Signed (54) (Representative)

(55) CERTIFICATE OF SHOP INSPECTION
Vessel constructed by at
I, the undersigned, holding a valid credential issued by the National Board of Boiler and Pressure Vessel Inspectors and Competent Authority and employed by
have inspected the component described in this Manufacturer's Data Report on , and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section XII.
By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, 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.
Date Signed (55) (Authorized Inspector) Commission (56) (National Board Commission Number and Endorsement)

FORM T-2AR MANUFACTURER'S PARTIAL DATA REPORT FOR CLASS 1 TRANSPORT TANKS
As Required by the Provisions of the ASME Code Rules, Section XII and Code Case 2705

1. Manufactured and certified by (1) (Name and address of Manufacturer)
2. Manufactured for (2) (Name and address of Purchaser)
3. Competent Authority (3) (Name of Regulatory Agency and Regulation Met)
4. Type (5) (DOT/UN Spec.) (6) (Manufacturer's serial No.) (7) (CRN)
5. ASME Code, Section XII (11) (Drawing No.) (12) (Drawing prepared by) (13) (Year built)
6. Shell: (a) No. of course(s) (14) (b) Overall length (15)

Table with columns: Course(s), Material, Thickness, Long. Joint (Cat. A), Circum. Joint (Cat A, B & C), Heat Treatment. Sub-columns include Diameter, Length, Spec./Grade or Type, Min., Corr., Type, Full, Spot, None, Eff., Type, Full, Spot, None, Eff., Temp., Time.

7. Heads: (a) (18) (25) (Material Spec. No., Grade or Type) (H.T. — Time & Temp.) (b) (Material Spec. No., Grade or Type) (H.T. — Time & Temp.)

Table for Head details with columns: Location (Top, Bottom, Ends), Thickness (Min., Corr.), Radius (Crown, Knuckle), Elliptical Ratio, Conical Apex Angle, Hemispherical Radius, Flat Diameter, Side to Pressure (Convex, Concave), Category A (Type, Full, Spot, None, Eff.).

If removable, bolts used (describe other fastenings) (30) (Material Spec. No., Grade, Size, No.)

8. MAWP (31) (32) (internal) (external) at max. temp. (32) (internal) (external) Min. design metal temp. (33) (32) at (34)

9. Impact test (34) at test temperature of (34) [Indicate yes or no and the component(s) impact tested]

10. Hydro., pneu., or comb. test press. (35) Proof test (36)

11. Nozzles, inspection and safety valve openings:

Table for Nozzles with columns: Purpose (Inlet, Outlet, Drain, etc.), No., Diameter or Size, Flange Type, Material (Nozzle, Flange), Nozzle Thickness (Nom., Corr.), Reinforcement Material, How Attached (Nozzle, Flange), Location (Insp. Open.).

12. Supports: Skirt (47) Lugs (47) Legs (47) Other (47) Attached (47) (Yes or no) (No.) (No.) (Describe) (Where and how)

13. Remarks (35) (36) (49)

(54) CERTIFICATE OF SHOP COMPLIANCE
We certify that the statements made in this report are correct and that all details of material, construction, and workmanship of this pressure vessel part conform to the ASME Code for Transport Tanks, Section XII, Class 1.
T Certificate of Authorization No. Expires
Date Name (Manufacturer) Signed (Representative)

(55) CERTIFICATE OF SHOP INSPECTION
I, the undersigned, holding a valid credential issued by the National Board of Boiler and Pressure Vessel Inspectors and/or Competent Authority of and employed by of
have inspected the pressure vessel part described in this Manufacturer's Data Report on and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel part in accordance with ASME Code, Section XII, Class 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel part described in this Manufacturer's Data Report. Furthermore, 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.
Date Signed (Authorized Inspector) Commission (National Board Commission Number and Endorsement)

FORM T-2CR MANUFACTURER'S PARTIAL DATA REPORT FOR CLASS 3 TRANSPORT TANKS
As Required by the Provisions of the ASME Code Rules, Section XII and Code Case 2705

1. Manufactured and certified by (Name and address of Manufacturer)
2. Manufactured for (Name and address of Purchaser)
3. Competent Authority (Name of Regulatory Agency and Regulation Met)
4. Type (DOT/UN Spec.) (Manufacturer's Serial No.) (CRN)
5. ASME Code, Section XII (Edition and Addenda (if applicable) (date)) (Code Case No.) Class Capacity
6. Shell: (a) No. of course(s) (b) Overall length

Table with 7 columns: Course(s), Material, Thickness, Long. Joint (Cat. A), Circum. Joint (Cat A, B & C), Heat Treatment. Sub-columns include Diameter, Length, Spec./Grade or Type, Min. Corr., Type, Full, Spot, None, Eff., Type, Full, Spot, None, Eff., Temp., Time.

7. Heads: (a) (Material Spec. No., Grade or Type) (H.T. — Time & Temp.) (b) (Material Spec. No., Grade or Type) (H.T. — Time & Temp.)

Table with 10 columns: Location (Top, Bottom, Ends), Thickness (Min, Corr), Radius (Crown, Knuckle), Elliptical Ratio, Conical Apex Angle, Hemispherical Radius, Flat Diameter, Side to Pressure (Convex, Concave), Category A (Type, Full, Spot, None, Eff.).

If removable, bolts used (describe other fastenings) (Material Spec. No., Grade, Size, No.)

8. MAWP (internal) (external) at max. temp. (internal) (external) . Min. design metal temp. (internal) (external) at

9. Impact test (indicate yes or no and the component(s) impact tested) at test temperature of

10. Hydro., pneu., or comb. test press. Proof test

11. Nozzles, inspection and safety valve openings:

Table with 8 columns: Purpose (Inlet, Outlet, Drain, etc.), No., Diameter or Size, Flange Type, Material (Nozzle, Flange), Nozzle Thickness (Nom., Corr.), Reinforcement Material, How Attached (Nozzle, Flange), Location (Insp. Open.).

12. Supports: Skirt (Yes or no) Lugs (No.) Legs (No.) Others (Describe) Attached (Where and how)

13. Remarks

(35) (36) (49)

54 CERTIFICATE OF SHOP COMPLIANCE
We certify that the statements made in this report are correct and that all details of material, construction, and workmanship of this pressure vessel part conform to the ASME Code for Transport Tanks, Section XII, Class 3.
T Certificate of Authorization No. Expires
Date Name (Manufacturer) Signed (Representative)

55 CERTIFICATE OF SHOP INSPECTION
I, the undersigned, holding a valid credential issued by the National Board of Boiler and Pressure Vessel Inspectors and/or Competent Authority of and employed by of
have inspected the pressure vessel part described in this Manufacturer's Data Report on ,
and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel part in accordance with ASME Code, Section XII, Class 3. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel part described in this Manufacturer's Data Report. Furthermore, 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.
Date Signed (Certified Individual)

Table 1
Guide for Completing Forms

References to Circled Numbers in the Forms	Description
(1)	Name and street address of manufacturer as listed on ASME Certificate of Authorization.
(2)	Name and address of purchaser.
(3)	Identify Competent Authority and regulation complied with.
(4)	U.S. DOT Specification/U.N. Specification.
(5)	Description of vessel part (i.e., shell, two-piece head).
(6)	Manufacturer's serial number.
(7)	Canadian registration number, where applicable.
(8)	Indicate drawing number(s), including applicable revision number, that cover general assembly and list of materials. For Canadian registered vessels, the number of the drawing approved by the provincial authorities.
(9)	Organization that prepared drawing, if other than the Manufacturer listed in (1).
(10)	Where applicable, the National Board number from the Manufacturer's Series of National Board numbers sequentially without skips or gaps. National Board numbers shall not be used for Owner-inspected vessels.
(11)	ASME Code, Section XII, Edition (e.g., 2004) and Addenda (e.g., A03, etc., if applicable) used for construction.
(12)	All Code Case numbers and revisions used for construction must be listed. Where more space is needed, use "Remarks" section or list on a supplemental page.
(13)	Indicate vessel capacity.
(14)	Total number of courses or sections between end closures (heads) required to make one shell. In the "No." blocks in the table below, under "Courses," indicate the number of courses with identical information.
(15)	Length of the shell (courses), excluding heads.
(16)	Indicate the dimensions of the course(s) as follows: <i>(a)</i> cylindricals as inside or outside diameter <i>(b)</i> transition as inside our outside diameter at the largest and smallest ends <i>(c)</i> squares or rectangles as the largest width and height <i>(d)</i> all other shapes define as appropriate or attach a sketch or drawing. Where more space is needed, use "Remarks" section or list on a supplemental page.
(17)	Length of the shell (courses), excluding heads.
(18)	Show the complete ASME material specification number and grade as listed in the appropriate stress allowance table in Section IV (e.g., "SA-285C"). Exception: A specification number for a material not identical to an ASME Specification may be shown only if such material has been approved for Section IV construction by an ASME interpretation case ruling and provided the applicable case number is also shown.
(19)	Thickness is the minimum required by the design or statute.
(20)	State corrosion allowance (see TD-130).
(21)	Type of longitudinal joint (e.g., Type 1, 2, 3, 4, 5, or 6) per Table TW-130.4. In case of brazing, explain type of joint. If seamless, indicate joint type as S, and E for electric resistance welded.
(22)	Category A (longitudinal) welds — identify degree of examination (radiographic or if applicable, ultrasonic) employed: full, spot, or none (see TE-230.1). Also identify the joint efficiency associated with the weld from Table TW-130.4. Where more space is needed, use "Remarks" section, supplemental page, or RT map, as applicable. In the case of parts, there is no need to identify the joint efficiency associated with these welds. [See (29) for heads of welded construction joints.]
(23)	Type of circumferential joint (e.g., Type 1, 2, 3, 4, 5, or 6) per Table TW-130.4. In the case of brazing, explain type of joint. For multiple course vessel, the Category B welds in the shell and head-to-shell joint (Category A, B, C) shall be listed bottom to top or left to right as shown on drawing listed in (8).
(24)	Categories A, B, and C (circumferential) welds — identify degree of examination (radiographic or if applicable, ultrasonic) employed: full, spot, or none (see TE-230.1) or spot radiography in accordance with TE-230.1(a)(4). Where more space is needed, use "Remarks" section, supplemental page, or RT map, as applicable. In the case of parts, there is no need to identify the joint efficiency associated with these welds.
(25)	When heat treatment is performed by the Manufacturer, such as postweld heat treatment, annealing, or normalizing, give the holding temperature and time. Explain any special cooling procedure under "Remarks."
(26)	Specified minimum thickness of the head after forming. It includes corrosion allowance.
(27)	Indicate the crown radius (inside or outside) for torispherical heads.
(28)	Indicate the knuckle radius (inside or outside) for torispherical heads.

Table 1
Guide for Completing Forms (Cont'd)

References to Circled Numbers in the Forms	Description
(29)	For heads of welded construction joints, indicate the following: (a) type of joint in the head (Category A), e.g., Type 1, 2, 3, etc., per Table TW-130.4; in the case of brazing, explain the type of joint. (b) identify degree of examination (radiographic or if applicable, ultrasonic) employed: full, spot, or none. Where more space is needed, use "Remarks" section, supplemental page, RT map, as applicable.
(30)	Bolts used to secure removable head or heads of vessel. Indicate the number, size, material specification (grade/type).
(31)	Show maximum allowable working pressure (internal or external) for which vessel is constructed. See TD-160.
(32)	Show maximum temperature permitted for vessel at MAWP. See (31).
(33)	Indicate the minimum design metal temperature (MDMT).
(34)	Indicate if impact testing was conducted (yes or no) and the component(s) that were impact tested and the impact test temperature. Where more space is needed, use "Remarks" section or list on a supplemental page. If no, indicate applicable paragraph(s) [such as TM-240.1, TM-240.3, TM-240.4(a), TM-240.4(b), TM-240.4(c), TM-250.5, and TM-250.7].
(35)	Indicate the type of test used (pneumatic, hydrostatic, or combination test, as applicable) and specify test pressure at the top of the vessel in the test position. Indicate under "Remarks" if the vessel was tested in vertical position.
(36)	When proof test is required by Code rules, indicate type of test (see Article TT-3), proof test pressure, and acceptance date by the Inspector. Subsequent Data Reports shall indicate under "Remarks" the test date, type, and acceptance date by the Inspector.
(37)	Nozzles, inspection, and safety valve openings; list all openings, regardless of size and use. Where more space is needed, list them on a supplemental page.
(38)	Indicate nozzles by the size (NPS) and inspection openings by inside dimensions in inches.
(39)	Data entries with description acceptable to the Inspector. For flange type, an abbreviation may be used to define any generic name. Some typical abbreviations: Flanged fabricated nozzle: Cl. 150 flg. Long weld neck flange: Cl. 300 lwn. Weld end fabricated nozzle: w.e. Lap joint flange: Cl. 150 lap jnt.
(40)	Show the material for the nozzle neck.
(41)	Show the material for the flange.
(42)	Nominal thickness applies to nozzle neck thickness.
(43)	Show the complete ASME specification number and grade of the actual material used for the reinforcement material (pad). Material is to be as designated in Section XII. EXCEPTIONS: A specification number for a material not identified to an ASME specification may be shown only if such material meets the criteria in the Code and in conjunction with the Foreword of this Section. When material is accepted through a Code Case, the applicable Case number shall be shown.
(44)	Data entries with description acceptable to the Inspector.
(45)	Categories C and D welds — identify degree of examination (radiographic or if applicable, ultrasonic) employed: full, spot, or none (see TE-230.1). Also identify the joint efficiency associated with the weld from Table TW-130.4.
(46)	"Location" applies to inspection openings only.
(47)	Describe: (a) type of support (skirt, lugs, etc.) (b) location of support (top, bottom, side, etc.) (c) method of attachment (bolted, welded, etc.)
(48)	To be completed when one or more parts of the vessel are furnished by others and certified on Data Report T-2A, B, or C. The part manufacturer's name and serial number should be indicated.
(49)	For additional comments including any Code restrictions on the vessel, or any unusual requirements that have been met, such as those in TG-100.2(c), TF-710(f)(1), etc., or in other notes to this Table. Indicate stiffening rings when used.
(50)	Fill in information identical to that shown on the Data Report Form to which this sheet is supplementary. Indicate the type of Certificate of Authorization, number, expiration date, and signature of the company representative.
(51)	Fill in information for which there was insufficient space on the Data Report Form as indicated by the notation "See attached T-3 Form" on the Data Report. Identify the applicable Data Report item number.

Table 1
Guide for Completing Forms (Cont'd)

References to Circled Numbers in the Forms	Description
(52)	Indicate data, if known.
(53)	Indicate the extent, if any, of the design function performed.
(54)	Certificate of Shop Compliance block is to show the name of the Manufacturer as shown on his ASME Code Certificate of Authorization. This should be signed in accordance with the organizational authority defined in the Quality Control System.
(55)	Certificate of Shop Inspection block is to be completed by the Manufacturer and signed by the Inspector who performs the inspection.
(56)	The Inspector's National Board credential number must be shown.

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Case 2706

Use of SB-584 (UNS C87500) Copper Alloy Sand Castings in the Manufacture of Nonstandard Pressure Parts for Hot Water Heating Boilers and Potable Water Heaters

Section IV

Approval Date: November 7, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS C87500 copper alloy sand castings, conforming to the requirements of SB-584, be used in the construction of hot water heating boilers and potable water heaters of Section IV pressure vessels?

Reply: It is the opinion of the Committee that UNS C87500 copper alloy sand castings, conforming to the requirements of SB-584, may be used in the construction of hot water heating boilers and potable water heaters of Section IV pressure vessels, provided the following requirements are met:

(a) The maximum allowable stress values shall be those listed in [Tables 1](#) and [1M](#).

(b) All other applicable parts of Section IV shall apply.

(c) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	HF-300.2, ksi [Note (1)]	HLW, ksi [Note (1)]
100	9.6	12.0
150	9.6	12.0
200	9.6	11.7
250	9.6	11.0 [Note (2)]

NOTES:

(1) With casting factor.

(2) These values are provided for interpolation only. The temperature limit is 210°F (99°C).

Table 1M
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °C	HF-300.2, MPa [Note (1)]	HLW, MPa [Note (1)]
40	66.0	83.0
65	66.0	82.0
100	66.0	76.0 [Note (3)]
125	66.0 [Note (2)]	...

NOTES:

(1) With casting factor.

(2) These values are provided for interpolation only. The temperature limit is 121°C.

(3) These values are provided for interpolation only. The temperature limit is 210°F (99°C).

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Case 2707

Use of SA-240/SA-240M UNS S41003 Plate in the Construction of Boilers

Section IV

Approval Date: November 7, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-240/SA-240M UNS S41003 plate be used in the construction of Section IV boilers?

Reply: It is the opinion of the Committee that SA-240/SA-240M UNS S41003 plate may be used for Section IV construction, provided the following requirements are met:

(a) The material shall conform to the requirements of SA-240/SA-240M UNS S41003.

(b) For external pressure design, Fig. CS-2 in Section II, Part D shall be used.

(c) For welding procedure and performance qualifications, the material shall be classified as P-No. 7, Group 1 in accordance with Section IX.

(d) The maximum design temperature shall be 500°F (260°C).

(e) After any thermal cutting, the cut face shall be ground or machined to a bright finish.

(f) Material shall be welded with a filler metal that produces a low carbon content austenitic chromium-nickel weld deposit (e.g., 309L).

(g) For gas metal arc welding processes using a solid wire or metal cored wire, the shielding gas shall have a maximum CO₂ content of 5%.

(h) The heat input during welding shall be controlled between 12.5 kJ/in. and 38 kJ/in. (0.5 kJ/mm and 1.5 kJ/mm).

(i) The interpass temperature shall not exceed 212°F (100°C).

(j) The preheating temperature shall be above 70°F (20°C).

(k) Maximum allowable stress values shall be as shown in [Table 1](#) and [Table 1M](#).

(l) Maximum allowable thickness shall not exceed ½ in. (12 mm).

(m) All other requirements of Section IV shall apply.

(n) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	13.2
200	13.2
300	13.2
400	12.9
500	12.4

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	91.0
100	91.0
150	91.0
200	89.0
250	86.2
300 [Note (1)]	83.4

NOTE: (1) Maximum use temperature is 260°C. The value at 300°C is furnished for interpolation only.

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Case 2708

Use of SA-240/SA-240M UNS S43035 (Grade 439) and UNS S43932 Less Than $\frac{1}{4}$ in. (6 mm) in Thickness for the Construction of Water Boilers Intended for Working Pressures Up to 160 psi (1100 kPa) Under Part HF

Section IV

Approval Date: November 7, 2011

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may boilers be constructed of UNS S43035 (Grade 439) and UNS S43932 materials that are less than $\frac{1}{4}$ in. (6 mm) thick, with a maximum working pressure higher than the 80 psi (550 kPa) established by HF-301.1(c)(1)?

Reply: It is the opinion of the Committee that boilers may be constructed of UNS S43035 (Grade 439) and UNS S43932 materials under SA-240/SA-240M that are less than $\frac{1}{4}$ in. (6 mm) in thickness and designed for pressures greater than 80 psi (550 kPa), in accordance with the requirements of Section IV, Part HF, provided the following conditions are met:

(a) The materials shall be used to construct only hot water heating boilers and hot water supply boilers for operation at pressures not exceeding 160 psi (1100 kPa) and water temperatures not exceeding 210°F (99°C).

(b) The materials shall not be exposed to primary products of combustion.

(c) The material thickness shall not be less than 0.065 in. (1.7 mm).

(d) All other requirements of Section IV shall be met in the construction of boilers or parts thereof.

(e) This Case number shall be shown on the Manufacturer's Data Report.

NOTE: This steel may develop embrittlement after service at moderately elevated temperatures; see Appendix A, A-340 and A-360, Section II, Part D.

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Case 2711-1

Use of AS 1548-2008 Grades PT430N/PT430NR, PT460N/ PT460NR, PT490N/PT490NR for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the steel grades PT430N/PT430NR, PT460N/PT460NR, PT490N/PT490NR, conforming to the Australian Standard AS 1548-2008¹ be used for the manufacture of pressure vessels to Section VIII, Division 2, Class 2?

Reply: It is the opinion of the Committee that the grades specified in the Inquiry and conforming to AS 1548-2008 may be used in Section VIII, Division 2, Class 2 construction, provided the following requirements are met:

(a) The maximum allowable stress values shall be as given in Tables 1 and 1M. The maximum design temperature is 1,000°F (538°C).

(b) Grades PT430 and PT460 shall be considered as P-No.1 Group 1; Grade PT490 shall be considered as P-No.1 Group 2.

(c) For the purpose of impact test requirements for Section VIII, Division 2, Class 2 use, PT430NR and PT460NR shall be considered Curve B; PT430N and PT460N shall be considered Curve D; PT490N and PT490NR shall be considered Curve A shown in Figures 3.7, 3.7M, 3.8, and 3.8M.

(d) For external pressure applications, use Fig. CS-2 of Section II, Part D.

(e) This Case number shall be shown on the Manufacturer's Data Report.

¹See Section II, Part A, Nonmandatory Appendix A for ordering information to obtain a copy of AS 1548-2008.

Table 1
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi		
	PT430N, PT430NR	PT460N, PT460NR	PT490N, PT490NR
-20 to 100	24.2	25.6	29.6
150	22.1	24.4	28.9
200	21.4	23.9	28.2
250	21.0	23.6	27.7
300	20.7	23.2	27.3
400	20.1	22.4	26.5
500	19.3	21.3	25.3
600	18.2	20.1	23.9
650	17.5	19.4	23.0
700	16.9	18.7	22.2
750	13.9	13.9	13.9
800	11.4	11.4	11.4
850	8.7	8.7	8.7
900	5.9	5.9	5.9
950	4.0	4.0	4.0
1000	2.5	2.5	2.5

Table 1M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa		
	PT430N, PT430NR	PT460N, PT460NR	PT490N, PT490NR
-30 to 40	167	177	204
65	153	168	200
100	147	164	194
125	144	162	191
150	142	160	188
175	141	158	186
200	139	155	183
225	137	152	180
250	134	149	176
300	128	141	168
325	124	137	163
350	120	133	157
375	114	114	114
400	95.0	95.0	95.0
425	79.6	79.6	79.6
450	63.2	63.2	63.2
475	45.3	45.3	45.3
500	31.7	31.7	31.7
525	21.9	21.9	21.9
550 [Note (1)]	12.7	12.7	12.7

NOTE: (1) These values are provided for interpolation purposes only. The maximum use temperature is 538°C.

Case 2712-2

Spherical Intermediate Head or End Closure Without Straight Flange

Section VIII, Division 1; Section VIII, Division 2

Approval Date: January 24, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible to attach a spherical head segment to a cylindrical shell section to form an intermediate head or end closure, as shown in [Figure 1](#), for Section VIII, Division 1 and Division 2 construction?

Reply: It is the opinion of the Committee that it is permissible to attach a spherical head segment to a cylindrical shell section to form an intermediate head or end closure, as shown in [Figure 1](#), for Section VIII, Division 1 and Division 2 construction, provided the following requirements are met:

(a) *Head Thickness*

(1) For Section VIII, Division 1, the head thickness shall be calculated in accordance with Section VIII, Division 1, Mandatory Appendix 1, 1-6(g)(1)(-a) and (-b) with P being the maximum pressure acting on either side. For pressure on the convex side of the head, Section VIII, Division 2, Part 4.4.7 may be used to determine the head thickness as an alternative to Mandatory Appendix 1, section 1-6. For differential pressure design, see UG-19(a). The maximum intermediate head dish radius, L , shall be limited to the shell inside diameter.

(2) For Section VIII, Division 2, the head thickness shall be calculated in accordance with Part 4.7.5.

(b) The stresses in the area of the head to shell joint shall be evaluated by elastic method in accordance with Parts 5.2.2 and 5.3.2 of Section VIII, Division 2. Allowable stresses used in the acceptance criteria shall be in accordance with the requirements of the applicable Division. The cyclic loading conditions shall be evaluated or exempted per Part 5.5 of Section VIII, Division 2.

(c) The weld shall be a full penetration through the head thickness (see [Figure 1](#)).

(d) When the shell base material is formed from plate, the region 9 in. (230 mm) or $(Rt_s)^{1/2}$, whichever is greater, above and below the weld centerline, shall be ultrasonically examined in accordance with SA-578, and the Level C acceptance criteria shall apply. R and t_s are the shell radius

and thickness, respectively. For all shell product forms, the completed weld shall be ultrasonically examined after any postweld heat treatment (PWHT) in accordance with

(1) Mandatory Appendix 12 for Section VIII, Division 1 construction, or

(2) Part 7.5.4 for Section VIII, Division 2 construction

(e) After welding and any PWHT, the weld joint shall be examined by

(1) magnetic particle examination in accordance with

(-a) Mandatory Appendix 6 for Section VIII, Division 1 construction

(-b) Part 7.5.6 for Section VIII, Division 2 construction

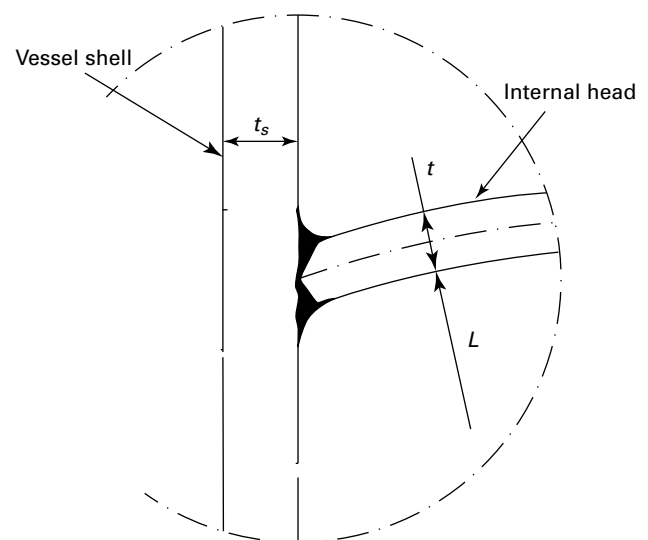
(f) In lieu of the examination described in (e), the weld joint may be examined by liquid penetrant examination in accordance with

(1) Mandatory Appendix 8 for Section VIII, Division 1 construction

(2) Part 7.5.7 for Section VIII, Division 1 construction

(g) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Full Penetration Weld



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Case 2715

Use of Glass Bull's-Eye Water Level Indicators on Electric Boilers

Section I

Approval Date: February 13, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an electric boiler be constructed and certified under Section I rules using glass bull's-eye water level indicators in lieu of externally mounted water gage glasses per the requirements of PEB-13?

Reply: It is the opinion of the Committee that an electric boiler may be constructed and certified under Section I rules using glass bull's-eye water level indicators in lieu of externally mounted gage glasses per the requirements of PEB-13 under the following conditions:

(a) The maximum allowable working pressure (MAWP) of the boiler shall not exceed 200 psig (1.5 MPa).

(b) The outside diameter of the boiler shell shall not exceed 16 in. (400 mm), and the volume of the boiler shell shall not exceed 5 ft³ (0.14 m³).

(c) The viewing port in the bull's-eye water level indicator assembly shall be made of glass compliant with ASTM E438.

(d) The viewing area of the window shall have a maximum diameter of 2³/₁₆ in. (55 mm).

(e) The bull's-eye water level indicator assembly shall be manufactured by a process that encases the entire thickness and circumference of the glass element in a metallic enclosure, creating a calculated compressive radial prestress not less than 18,000 psi (120 MPa).

(f) The glass bull's-eye water level indicator shall be located to provide a visible water level indication not less than 1 in. (25 mm) above the lowest permissible water level recommended by the boiler Manufacturer.

(g) When more than one water level indicator is necessary to ensure a complete visible range of water level indications from the low water cutoff level to the normal operating water level for all operating and transient conditions, the water level indicators shall be located adjacent to one another and shall be arranged to ensure a minimum of 1 in. (25 mm) in overlapping water level indication.

(h) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2718

Alternative Minimum Test Temperature for Hydrostatic Testing

Section VIII, Division 2

Approval Date: March 21, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a Manufacturer apply the required hydrostatic test to a complete Section VIII, Division 2 pressure vessel at a metal temperature colder than 30°F (17°C) above the minimum design metal temperature (MDMT) stamped on the nameplate as required by para. 8.2.4(a)?

Reply: It is the opinion of the Committee that the required hydrostatic test may be applied to a complete Section VIII, Division 2 pressure vessel at a metal temperature colder than 30°F (17°C) above the MDMT stamped on

the nameplate as required by para. 8.2.4(a), under the following conditions:

(a) The base metals, weld metals, and heat affected zones (HAZ) of all components listed in 3.11.1.1 are qualified by impact testing at test temperatures colder than the stamped MDMT of the vessel, or meet the requirements for exemption from impact testing for an MDMT colder than the stamped MDMT of the vessel under the rules of Division 2.

(b) The metal temperature during the hydrostatic test shall be maintained at least 30°F (17°C) warmer than the warmest impact test or exemption temperature determined in para. (a).

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2719

Use of EN 10088-2 Gr. X6CrNiMoTi 17-12-2 Sheet, Plate, and Strip in the Construction of Boilers

Section IV

Approval Date: April 4, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may EN 10088-2 Gr. X6CrNiMoTi 17-12-2 sheet, plate, and strip be used in the construction of Section IV boilers?

Reply: It is the opinion of the Committee that EN 10088-2 Gr. X6CrNiMoTi 17-12-2 sheet, plate, and strip may be used for Section IV construction, provided the following:

(a) *Extent of Testing.* The tensile tests at room temperature for strips and sheets cut from strips in rolling width less than 600 mm shall be performed on one test sample from each coil.

(b) For external pressure design, use Figure HA-2 of Section II, Part D.

(c) Maximum allowable stress value shall be as shown in Tables 1 and 1M.

(d) *Resurfacing by Welding.* If repairs are authorized by the purchaser, the following requirements have to be fulfilled:

(1) Preparation for repair welding shall include inspection to ensure complete removal of the defect.

(2) Repairs shall be made utilizing welding procedures qualified in accordance with Section IX, and repair welding shall be done by welders or welding operators meeting the qualification requirements of Section IX.

(e) All other requirements of Section IV shall apply.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi		
	$t \leq \frac{5}{16}$ in.	$\frac{5}{16}$ in. < $t \leq \frac{1}{2}$ in.	$\frac{1}{2}$ in. < $t \leq 3$ in.
100	15.7	15.7	15.1
150	15.7	15.7	15.1
200	15.7	15.7	15.1
250	15.4	15.4	14.9
300	15.2	15.2	14.7
350	15.1	15.1	14.5
400	15.0	15.0	14.5
450	15.0	14.6	14.4
500	15.0	14.1	14.1

Table 1M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa		
	$t \leq 8$ mm	8 mm < $t \leq 13$ mm	13 mm < $t \leq 75$ mm
40	108	108	104
65	108	108	104
100	108	108	104
125	106	106	102
150	105	105	101
175	104	104	100
200	104	104	100
225	103	102	100
250	103	98.2	98.2
275 [Note (1)]	103	95.1	95.1

NOTE: (1) The maximum use temperature shall be 260°C. Data for 275°C temperature is provided for interpolation purposes.

Case 2720

Use of EN 10025-2 Gr. S235JR Plate in the Construction of Boilers

Section IV

Approval Date: April 4, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may EN 10025-2 Gr. S235JR plate be used in the construction of Section IV boilers?

Reply: It is the opinion of the Committee that EN 10025-2 Gr. S235JR plate may be used for Section IV construction, provided the following:

(a) The maximum copper content in the heat analysis shall be limited to 0.40%.

(b) For external pressure design, use Figure CS-2 of Section II, Part D.

(c) Maximum allowable stress value shall be 10.4 ksi (72.0 MPa).

(d) The maximum thickness shall be 4 in. (100 mm).

(e) *Resurfacing by Welding.* If resurfacing by welding is acceptable by agreement with the purchaser, the following requirements have to be fulfilled:

(1) Preparation for repair welding shall include inspection to ensure complete removal of the defect.

(2) Repairs shall be made utilizing welding procedures qualified in accordance with Section IX, and repair welding shall be done by welders or welding operators meeting the qualification requirements of Section IX.

(f) All other requirements of Section IV shall apply.

(g) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2721

Use of EN 10217-1 Gr. P235TR2 Tubes in the Construction of Boilers

Section IV

Approval Date: April 4, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may EN 10217-1 Gr. P235TR2 tubes be used in the construction of Section IV boilers?

Reply: It is the opinion of the Committee that EN 10217-1 Gr. P235TR2 tubes may be used for Section IV construction, provided the following:

(a) The tubes shall be made using the high frequency welding (HFW) process only.

(b) For external pressure design, use Figure CS-2 of Section II, Part D.

(c) Maximum allowable stress value shall be 8.8 ksi (61.2 MPa). This stress value includes a joint factor of 0.85.

(d) The maximum thickness shall be $1\frac{9}{16}$ in. (40 mm).

(e) *Resurfacing by Welding.* Repair welding is not permitted without specific approval by the purchaser. If repairs are authorized by the purchaser, the following requirements have to be fulfilled:

(1) Preparation for repair welding shall include inspection to ensure complete removal of the defect.

(2) Repairs shall be made utilizing welding procedures qualified in accordance with Section IX, and repair welding shall be done by welders or welding operators meeting the qualification requirements of Section IX.

(f) All other requirements of Section IV shall apply.

(g) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2722-1

Use of SA-240/SA-240M, Alloys 439 and UNS S43932, and SA-268, alloy TP439 Up to 210°F (99°C) in Heating Boiler Construction

Section IV

Approval Date: October 25, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SA-240/SA-240M, alloys 439 and UNS S43932, and SA-268, alloy TP439 (UNS S43035) be used in Section IV heating boiler construction for water temperatures up to 210°F (99°C)?

Reply: It is the opinion of the Committee that SA-240/SA-240M, Alloys 439 and UNS S43932, and SA-268, alloy TP439 (UNS S43035) may be used in Section IV heating

boiler construction for water temperatures up to 210°F (99°C), provided the following additional requirements are met:

(a) Maximum material thickness shall not exceed $\frac{3}{8}$ in. (9.53 mm).

(b) Maximum allowable stress values shall be as listed in Tables HF-300.1 and HF-300.1M, except that the maximum allowable water temperature shall be 210°F (99°C).

(c) This Case number shall be shown on the applicable Data Report.

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Case 2723

UNS S31635 Tubing for Construction of Water Heaters

Section IV

Approval Date: April 4, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S31635 austenitic stainless steel in SA-213/SA-213M TP316Ti be used in the construction of water heaters?

Reply: It is the opinion of the Committee that UNS S31635 austenitic stainless steel in SA-213/SA-213M TP316Ti may be used in the construction of water heaters, provided the following requirements are met:

(a) The allowable stress values for the tubing in accordance with SA-213/SA-213M TP316Ti shall be as listed in [Tables 1](#) and [1M](#).

(b) For the purpose of welding procedure and performance qualification, this material shall be considered P-No. 8, Group 1.

(c) For external pressure, Figure HA-2 of Section II, Part D shall be used.

(d) The maximum design temperature shall be 500°F (260°C).

(e) The water temperature shall not exceed 210°F (99°C).

(f) The water heaters shall not be used for comfort heating applications.

(g) All other requirements of Section IV shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for
SA-213/SA-213M TP316Ti

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	18.8
150	18.7
200	17.7
250	16.7
300	15.9
400	14.3
500	13.2

GENERAL NOTE: This material may utilize the minimum thickness exemption as shown in HF-301.1(c).

Table 1M
Maximum Allowable Stress Values for
SA-213/SA-213M TP316Ti

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	129
100	120
150	109
200	99.3
225	95.3
250	92.0
275 [Note (1)]	89.3

GENERAL NOTE: This material may utilize the minimum thickness exemption as shown in HF-301.1(c).

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

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Case 2724

Use of ER310 Filler Metals to Weld UNS S43035, Grades 439 and TP439 Materials to Austenitic Grades 304, 304L, 316, 316L, and 316Ti for the Construction of Heating Boilers

Section IV

Approval Date: April 4, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ER310 filler metals be used to weld SA-240/SA-240M, Grade 439 and SA-268, Grade TP439 materials to the following: SA-240/SA-240M, Grades 304, 304L, 316, 316L, 316Ti; SA-213/SA-213M, Grades TP304, TP304L, 316; and SA-249, Grades TP304, TP304L, TP316, and TP316L for the construction of heating boilers under Section IV, Part HF?

Reply: It is the opinion of the Committee that ER310 filler metals may be used to weld Grades 439/TP439, P-No. 7 materials to Grades 304/TP304, 304L/TP304L, 316/TP316, 316L/TP316L and 316Ti, P-No. 8 materials in Section IV, Part HF construction, provided the following conditions are met:

- (a) SFA-5.9, ER310 filler metal shall be used.
- (b) All Notes to Table HF-300.1 pertaining to the materials of construction will apply except Note (15).
- (c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2725-1

Polymer Material for Heating Boiler Components

Section IV

Approval Date: October 6, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May ASTM D 4349-16, grades PPE0410G30A40346 and PPE0210G30A50553 polymers be used for the construction of boiler components in Section IV?

Reply: It is the opinion of the Committee that ASTM D 4349-16, grades PPE0410G30A40346 and PPE0210G30A50553 polymers may be used for the construction of Section IV boiler components, provided the following requirements are met.

1 GENERAL REQUIREMENTS

(a) The polymer materials shall be in compliance with ASTM D4349-16 and shall be limited to the polymers with a classification designation of PPE410G30A40346 and PPE0210G30A50553.

(b) The polymer materials shall be certified by the materials manufacturer, and a report of test results shall be furnished to the boiler manufacturer for each lot¹ of material.

(c) The material shall not be used for heat transfer purposes and shall not be exposed to direct flame. The material may be exposed to the products of combustion, but the maximum flue gas temperature shall not exceed 212°F (100°C).

(d) The boiler shall be limited to hot water heating service.

(e) The maximum heat input shall be limited to 256,000 Btu/hr (75 kW).

(f) The maximum allowable working pressure shall not exceed 50 psi (345 kPa).

(g) The maximum material design and water temperature shall not exceed 210°F (99°C).

(h) The maximum water temperature shall be stamped on the ASME nameplate and documented on the Manufacturer's Data Report.

(i) The maximum water volume of the polymer parts shall not exceed 1.85 gal (7 L).

(j) The polymer material shall not be repaired.

(k) The polymer parts shall have a permanently attached label or marking stating, "Repair of the polymer parts is prohibited."

(l) The polymer parts shall be permanently marked in a manner to provide traceability to the material manufacturer's report of test results and to the injection molding machine.

(m) The injection molding process shall be controlled by a written procedure in which all of the following process variables shall be considered essential:

- melting temperature
 - nozzle
 - front
 - middle
 - rear
- mold temperature
- drying time (average)
- drying time (maximum)
- moisture content (% , maximum)
- back pressure
- screw speed
- ratio of shot size to cylinder size
- weight of finished molded part

(n) A change of any of the essential variables in (m) shall require requalification of the written procedure per the test procedure specified in section 2.

(o) The Authorized Inspector (AI) shall monitor the injection molding process to ensure compliance with the written procedure. The AI shall verify that the manufacturer has performed all steps in sections 1, 2, and 3.

(p) Material used for qualification testing shall not be used on Code stamped boilers.

(q) The use of regrind material is prohibited.

(r) This Case number shall be shown on the Manufacturer's Data Report.

(s) The Manufacturer's quality control system shall address use of polymers for injection molded parts.

(t) Joining to other parts shall be only by mechanical methods. Fusion bonding is not allowed.

(u) After using mold release agents, the first five parts shall be scrapped.

(v) Adding colorant to the polymer is prohibited.

¹The term "lot" is a continuous production run of finished polymer material in pellet or granular form that has been assigned a unique identification number and issued a certificate of compliance by the polymer manufacturer.

(w) The polymer shall not have line of sight to the flame to prevent degradation as a result of UV radiation.

(x) All finished products (boiler) using these polymer parts shall be subject to a hydrostatic test per HG-510.

(y) All other requirements of Section IV shall apply.

(z) The production of the polymer parts may be subcontracted, but the production of these parts shall be witnessed by a representative of the boiler Manufacturer (Stamp Holder) and the boiler Manufacturer's AI. The design qualification of the polymer parts per section 2 of this Case shall remain the responsibility of the boiler Manufacturer.

2 DESIGN QUALIFICATION

The qualification of the polymer part design shall be by testing of one or more full-size prototype parts by the following test sequence:

(a) The weight of the prototype parts shall be measured to an accuracy of 1.25%.

(b) The weight of the part shall be within the range specified in the injection molding procedure.

(c) The part shall be examined for conformance with dimensions and tolerances shown on the design drawings.

(d) *Water Cycling Pressure Test.* Pressure shall be raised from atmospheric pressure to MAWP and back 100,000 times at maximum design temperature.

(e) *Water Cycling Temperature Test.* The water temperature shall be raised from 59°F (15°C) to the maximum design temperature and back 100,000 times at the MAWP.

(f) After successful completion of the cyclic tests specified in (d) and (e), the same prototype parts shall then be subjected to a design qualification pressure test. This pressure test shall be conducted using water at the maximum design temperature. The test pressure applied shall be a minimum of 6 times the MAWP of the part and shall be raised from zero to this pressure in no less than 1 min and held for 5 min. Test to failure is not required. If the prototype part exhibits any leakage, cracking, or bursts during the application of pressure, or during the required hold time, the prototype shall be considered to have failed and requalification shall be required.

$$P = B/6$$

where

B = bursting test pressure, psi (kPa)

P = design pressure, psi (kPa)

= MAWP, psi (kPa)

(g) The AI shall verify the cyclic pressure and temperature tests and shall witness and accept the design pressure test.

(h) The specified weight of each part shall be reported in the proof test report.

(i) Classification and acceptance level of imperfections shall be according to Table 1.

3 PRODUCTION OF POLYMER PARTS

3.1 GENERAL REQUIREMENTS

(a) Production of polymer parts may begin when the injection molding parameters [see 1(m)] are stable and within tolerance as defined in the injection molding procedure. The parameters shall be recorded at the beginning of production. Further, the injection molding machine shall be monitored during production, and the parameters [see 1(m)] shall be recorded once per hour minimum for review by the AI.

(b) The first ten parts produced are to be used for start-up purposes only. These ten parts shall not be considered part of the production batch and shall be scrapped. The following parts shall be monitored as defined in 3.2.

(c) Each production part shall be weighed by a scale calibrated to an accuracy of $1/10$ of the tolerance range, and the weight of parts shall not be less than 98.75% of the weight of the prototype unit.

3.2 INSPECTION OF PRODUCTS

There are two acceptable methods for inspection of the products: a 100% inspection as described in (a) or statistical methods described in (b). For the statistical methods, there are two alternatives described: Statistical Process Control (SPC) [see (b)(1)] or two sample T-test method [see (b)(2)].

(a) *Inspection at 100%*

(1) Each polymer part shall be examined internally and externally for imperfections. Classification and acceptance level of imperfections shall be according to Table 1.

(2) The first ten parts in a production batch² shall be examined for conformance per the design drawings. Any dimension outside the specified limit shall be cause for rejection.

(3) Every tenth part after the first ten parts in a production batch shall be examined for conformance with dimensions and tolerances shown on the design drawings. Any dimension outside the specification limits shall be cause for rejection of that part and the previous parts in the production batch. The previously rejected parts in the production batch shall be thoroughly examined, and shall meet all requirements of this Code Case, or shall be scrapped. The injection molding process shall be requalified before production is resumed.

(4) At least one part per 1,000 parts shall be subjected to the requirements identified in 2(b) through 2(i). The parts to be used for these tests shall be selected at random by the Authorized Inspector. If the part(s) fail any of these tests, the complete batch

²The term "production batch" is a continuous production run of molded parts from each individual injection molding machine.

shall be scrapped, including the remainder of the parts. The production process shall be requalified per section 2.

(b) Inspection by Statistical Control Methods

(1) Statistical Process Control (SPC)

(-a) The Manufacturer shall use ASTM E2281-15, Standard Practice for Process and Measurement Capability Indices, to evaluate process capability and performance.

(-b) The Manufacturer shall comply with ASTM E2587-16, Standard Practice for Use of Control Charts in Statistical Process Control, and demonstrate the following items:

(-1) critical variables defined on design drawings of the part; as a minimum the outer dimensions of length, height, and width

(-2) part weight

(-3) visual inspection of the part according to

Table 1

(-c) The Manufacturer shall comply with the following:

(-1) minimum C_p value of 1.67

(-2) minimum C_{pk} value of 1.33

(-d) If the C_p and/or C_{pk} values go below the minimum values stated in *(-c)*, then each part in the production batch shall be thoroughly examined, and shall meet all requirements of this Code Case, or shall be scrapped. The injection molding process shall be requalified before production is resumed.

(2) The Two Sample T-Test Method

(-a) The Manufacturer shall establish a control sample such that all parts within the sample are acceptable. The control sample shall be 100 parts, minimum.

(-b) The T-test shall be based on critical variables such as the outer dimensions of length, height, and width. As a minimum, the weight of the polymer part shall be used for the T-test.

(-c) The T-test shall be performed:

(-1) at the beginning and end of each production batch²

(-2) at initial production for each lot¹ of polymer material

(-3) each production sample shall consist of a minimum sample size of 20 production parts.

(-4) each production sample shall be compared to the control sample.

(-5) the calculated t value shall be less than or equal to the tabulated t value at $p = 0.01$

(-6) if the calculated t value is greater than the tabulated t value, then each part in the production batch shall be thoroughly examined, and shall meet all requirements of this Case, or shall be scrapped. The injection molding process shall be requalified before production is resumed.

Table 1
Visual Acceptance Criteria

Defect	Definition	Maximum Size
Black spots, brown streaks	Dark spots or streaks	None permitted
Blister	Hollows on or in the parts	Pressure side: none permitted; Nonpressure side: maximum diameter, $\frac{1}{16}$ in. (1.5 mm); maximum density 1 per 1 ft ² (1 per 0.1 m ²), none less than 2 in. (50 mm) apart
Bubbles	Air entrapped in the parts	Maximum diameter: $\frac{1}{16}$ in. (1.5 mm), maximum density: 4 per 1 in ² (4 per 650 mm ²); maximum diameter: $\frac{1}{16}$ in. (1.5 mm), maximum density 10 per 1 in. ² (10 per 650 mm ²)
Burn marks, dieseling	Charred or dark plastic caused by trapped gas	None permitted
Cracking, crazing	Any visible	None permitted
Delamination	Single surface layers flake off parts	None permitted
Discoloration	Similar to burn marks but generally not as dark or severe	Acceptable
Flow, halo, blush marks	Marks seen on the part due to flow of molten plastic across the molding surface	Acceptable
Gels	Bubbles or blisters on or in the part due to poor melt quality	None permitted
Jetting	Undeveloped frontal flow	None permitted

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Case 2726

Hydrostatic and Pneumatic Testing of Mass-Produced Pressure Vessels With an Intermediate Isolation Valve Between Indicating Gage and Pressure Vessel

Section VIII, Division 1

Approval Date: May 24, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: When is it permissible during hydrostatic or pneumatic testing to place an intermediate isolation valve between an indicating gage required in UG-102(a) and a pressure vessel constructed to the requirements of UG-90(c)(2) and Appendix 35 of Section VIII, Division 1?

Reply: It is the opinion of the Committee that it is permissible during hydrostatic or pneumatic testing of mass-produced vessels constructed in accordance with UG-90(c)(2) and Appendix 35 of Section VIII, Division 1 to place an intermediate isolation valve between the pressure vessel and the indicating gage required by UG-102(a) when the following conditions are met:

(a) The pressure vessel is tested in a test enclosure, and the test enclosure may not provide adequate access to perform inspection in accordance with 35-6(f).

(b) The intermediate isolation valve is required to maintain pressure in the vessel at a value of test pressure divided by 1.3 while the vessel is moved from the test enclosure to a location where inspection for leakage is performed.

(c) There shall be administrative procedures or valve operation controls to ensure that the intermediate isolation valve is maintained to its full, open position assuring that the pressure vessel is tested to the prescribed test pressure.

(d) The manufacturer's pressure test operating procedures shall describe the following:

(1) requirements, operator actions and check points for performing the pressure test and leakage inspection.

(2) the intermediate isolation valve setup and operating positions. If electric or pneumatic controlled valves are used in the test cell, an explanation of the indicating lights, valve positions, and valve fail open/closed positions shall be provided.

(e) The indicating gage required by UG-102(a) shall not be isolated from the source of pressure by the intermediate isolation valve.

(f) This Case number shall be noted on the Manufacturer's Data Report for the vessel.

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Case 2727-1

22Cr-5Ni-3Mo-N (UNS S31803) Use to 600°F (316°C) for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 22Cr-5Ni-3Mo-N (UNS S31803) forgings, plate, seamless and welded tube, and seamless and welded pipe in accordance with SA-182, SA-240, SA-789, and SA-790, respectively, be used in Section VIII, Division 2, Class 2 welded construction at temperatures up to and including 600°F (316°C)?

Reply: It is the opinion of the Committee that 22Cr-5Ni-3Mo-N (UNS S31803) forgings, plate, seamless and welded tube, and seamless and welded pipe in accordance with SA-182, SA-240, SA-789, and SA-790, respectively, may be used in Section VIII, Division 2, Class 2 welded construction at temperatures up to and including 600°F (316°C), provided the following additional requirements are met:

(a) The rules for austenitic-ferritic duplex stainless steels in Section VIII, Division 2, Class 2 shall apply.

(b) The maximum allowable stress values shall be as given in Tables 1 and 1M. The maximum design temperature shall not exceed 600°F (316°C). For welded tube or pipe, a joint efficiency factor of 0.85 shall be used.

(c) This steel may be expected to develop embrittlement after service at moderately elevated temperature; see Appendix A, A-340 and A-360.

(d) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi
500	33.1
600	31.9

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa
250	229
275	226
300	223
325 [Note (1)]	219

NOTE: (1) This value is provided for interpolation purposes only; the maximum design temperature shall be per (b) of the Reply.

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Case 2728-1

Use of SB-564 Nickel-Iron-Chromium-Molybdenum-Copper Alloy UNS N08825 Forgings for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SB-564 nickel-iron-chromium-molybdenum-copper alloy, UNS N08825 forgings be used in Section VIII, Division 2, Class 2 construction?

Reply: It is the opinion of the Committee that SB-564 nickel-iron-chromium-molybdenum-copper alloy UNS N08825 forgings may be used in Section VIII, Division 2, Class 2 construction, provided the following additional requirements are met:

(a) Section II, Part D, Table 5B maximum allowable stress values shall be those for SB-424, UNS N08825.

(b) All other Section VIII, Division 2, Class 2 requirements for UNS N08825 shall apply.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2729-2

Fabrication of Class I Vessels With Metallic Nozzles Not Meeting Minimum Wall Thickness Requirements

Section X

Approval Date: April 3, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to fabricate Section X, Class I vessels with metallic nozzles that do not meet the minimum wall thickness requirements of UG-45, Section VIII, Division 1 as required by RG-100(c) and RM-211, Section X?

Reply: It is the opinion of the Committee that Section X, Class I vessels may be fabricated with metallic nozzles that do not meet the minimum wall thickness requirements of UG-45, Section VIII, Division 1 as required by RG-100(c) and RM-211, Section X subject to the following:

(a) The minimum wall thickness of nozzle necks shall be determined as follows:

(1) For access openings and openings used only for inspection:

$$t_r = t_a$$

(2) For other nozzles:

t_a = minimum neck thickness required for internal and external pressure using UG-27 and UG-28 of Section VIII, Division 1 (plus corrosion allowance), as applicable. The effects of external forces and moments from supplemental loads (see UG-22, Section VIII, Division 1) shall be considered. Shear stresses shall not exceed 70% of the allowable tensile stress for nozzle material.

t_{b1} = thickness given in Table UG-45 of Section VIII, Division 1 plus the thickness added for corrosion allowance

$$t_r = \max. (t_a, t_{b1})$$

(b) The minimum nozzle wall thickness for piping connections using a groove in the nozzle end to restrain the piping shall be determined as follows:

t_{b2} = minimum neck thickness required for internal and external pressure using UG-27 and UG-28 of Section VIII, Division 1. The effects of external

forces and moments from supplemental loads (see UG-22, Section VIII, Division 1) shall be considered. Shear stresses shall not exceed 70% of the allowable tensile stress for nozzle material.

t_{b3} = minimum nozzle wall thickness at the bottom of the groove shall not be less than the thickness shown in Table 1

$t_{rg} = \max. (t_{b2}, t_{b3})$. See Figure 1.

(c) Grooved nozzle ends for piping connections are prohibited except for the pipe sizes shown in Table 1.

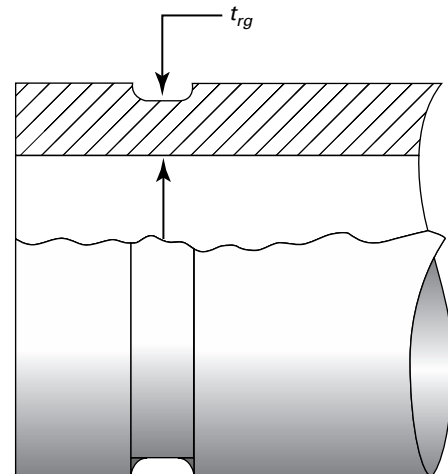
(d) When grooved nozzle ends are used for pipe sizes shown in Table 1, the inside corner radius at the bottom of the groove shall be 0.015 in. (0.381 mm) minimum to 0.030 in. (0.762 mm) maximum.

(e) The maximum allowable nozzle design stress at maximum allowable working pressure shall be 25.1 ksi (173 MPa).

(f) The maximum internal design pressure shall be 1,200 psi (8.27 MPa).

(g) This Case number shall be shown on the Fabricator's Data Report.

Figure 1
Minimum Nozzle Wall Thickness for Piping Connection Using a Groove in the Nozzle End



GENERAL NOTE: Exaggerated for clarity.

Table 1
Minimum Groove Wall Thickness

Nominal Pipe Size, in. (DN)	Minimum Groove Wall Thickness, t_{b3}, in. (mm)
$\frac{3}{4}$ (20)	0.033 (0.838)
1 (25)	0.044 (1.118)
1 $\frac{1}{2}$ (40)	0.055 (1.397)
2 (50)	0.055 (1.397)
2 $\frac{1}{2}$ (65)	0.083 (2.108)
3 (80)	0.093 (2.362)
4 (100)	0.106 (2.692)

Case 2730

Allowable Stresses and Design Stress Intensities for Bolting Materials Listed in Both Tables 3 and 4 of Section II, Part D

Section VIII, Division 2

Approval Date: June 28, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible to use allowable stresses for bolting materials listed in Table 3 of Section II, Part D in lieu of the design stress intensity values listed in Table 4 of Section II, Part D for pressure vessels constructed in accordance with Section VIII, Division 2, Part 5?

Reply: It is the opinion of the Committee that the allowable stresses for bolting materials listed in Table 3 of Section II, Part D may be used in lieu of the design

stress intensity values listed in Table 4 of Section II, Part D for pressure vessels constructed in accordance with Section VIII, Division 2, Part 5 under the following conditions:

(a) The bolting material shall have the same specification, grade, and minimum specified yield and tensile strengths listed in both Table 3 and Table 4 of Section II, Part D.

(b) The material and size of the bolts shall be identified on the Manufacturer's Data Report in the Remarks section.

(c) This Case number shall be shown on the Manufacturer's Data Report and marked on the nameplate.

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Case 2731

Exemption From Mandatory Requirement for Fusible Plug in Hand-Fired Boilers

Section I

Approval Date: May 16, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Until such time as the revision to Section I removing the mandatory requirement for a fusible plug in hand-fired boilers in PFT-52 is published, is it

permissible to manufacture hand fired boilers without a fusible plug?

Reply: It is the opinion of the Committee that it is permissible to manufacture hand fired boilers without a fusible plug as required by PFT-52, provided all other applicable requirements of Section I are met, and this Case number is recorded on the Manufacturer's Data Report.

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Case 2733-3

F-Number Grouping for Ni-Fe-Cr, Classification UNS N08087 Welding Filler Metal

Section I; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX

This Case number shall be shown on the Manufacturer's Data Report.

Approval Date: August 1, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternate rules may be applied to grouping UNS N08087, Ni-Fe-Cr welding filler metal meeting the chemical properties of [Table 1](#) but otherwise conforming to AWS A5.14 to reduce the number of welding performance qualifications?

Reply: It is the opinion of the Committee that UNS N08087, Ni-Fe-Cr welding electrodes meeting the chemical properties of [Table 1](#) but otherwise conforming to AWS A5.14 may be considered as F-No. 43 for welding performance qualifications only. Separate welding procedure qualifications are required. Welding shall be limited to the GTAW, GMAW, and SAW processes. Further, this material shall be identified as UNS N08087 in the Welding Procedure Specification, Welding Procedure Qualification Record, and Welder Performance Records.

Table 1
Chemical Requirements

Element	Composition, %
C	0.08–0.14
Mn	1.2–1.8
Si	0.05–0.50
P	0.01 max.
S	0.01 max.
Ni	54 max.
Cr	8.0–9.5
Mo	1.8–2.2
Nb	0.90–1.40
B	0.0005–0.002
Al	0.10–0.20
Cu	0.25 max.
N	0.02 max.
Fe	38–42

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Case 2734-3

F-Number Grouping for Ni-Fe-Cr, Classification UNS N08087 Welding Electrode

Section I; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX

Approval Date: August 1, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternate rules may be applied to grouping UNS N08087, Ni-Fe-Cr welding electrodes meeting the chemical properties of [Table 1](#) and mechanical properties of [Table 2](#) but otherwise conforming to AWS A5.11/A5.11M to reduce the number of welding performance qualifications?

Reply: It is the opinion of the Committee that UNS N08087, Ni-Fe-Cr welding electrodes meeting the chemical properties of [Table 1](#) and mechanical properties of [Table 2](#) but otherwise conforming to AWS A5.11/A5.11M may be considered as F-No. 43 for welding performance qualifications only. Separate welding procedure qualifications are required. Further, this material shall be identified as UNS N08087 in the Welding Procedure Specification, Welding Procedure Qualification Record, and Welder Performance Records.

This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
C	0.08–0.14
Mn	1.2–1.8
Si	0.05–0.50
P	0.01 max.
S	0.01 max.
Ni	54 max.
Cr	8.0–9.5
Mo	1.8–2.2
Nb	0.90–1.40
B	0.0005–0.002
Al	0.10–0.20
Cu	0.25 max.
N	0.02 max.
Fe	38–42

Table 2
Mechanical Property Requirements (Room Temperature)

Property	Values
Tensile strength, min., ksi (MPa)	80 (560)
Yield strength, 0.2% min., ksi (MPa)	52 (360)
Elongation in 2 in. (50 mm), %	25

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Case 2735

Use of UNS S82011 Stainless Steel

Section VIII, Division 1

Approval Date: September 25, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible in welded construction conforming to the rules of Section VIII, Division 1 to use UNS S82011 wrought ferritic/austenitic stainless steel as seamless and welded pipe and tube, and plate, conforming to the composition requirements of [Table 1](#), the mechanical property requirements of [Table 2](#), and otherwise conforming to the requirements of SA-240, SA-789, and SA-790, as applicable?

Reply: It is the opinion of the Committee that the materials described in the Inquiry may be used in Section VIII, Division 1 construction, provided the following requirements are met:

(a) The material shall be furnished in the heat treated condition. The heat treatment shall be performed in the range of 1,850°F to 2,050°F (1 010°C to 1 120°C) with subsequent rapid cooling.

(b) The rules for austenitic-ferritic stainless steels in Section VIII, Division 1, Subsection C, Part UHA shall apply.

(c) The design temperature shall not exceed 650°F (343°C).

(d) The maximum allowable design stress values shall be those listed in [Tables 3](#) or [3M](#). For welded pipe and tube, a joint efficiency factor of 0.85 shall be used.

(e) For external pressure design, use Fig. HA-5 of Section II, Part D.

(f) This material shall be considered P-No. 10H Group 1.

(g) Heat treatment after welding is neither required nor prohibited. However, if heat treatment is applied, the treatment shall be as noted in [\(a\)](#).

(h) Tensile and yield strengths at temperature are shown in [Tables 4](#), [4M](#), [5](#) and [5M](#).

(i) Physical properties shall be taken from Section II, Part D, Subpart 2 using the values from Table TE-1, Group 2 for thermal expansion; Table TCD, Material Group J for thermal conductivity and thermal diffusion; Table TM-1, Material Group H for elastic modulus; and Table PRD, high alloy steels (200 series) for Poisson's ratio and density.

(j) This Case number shall be included in the material documentation and marking and shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Weight, %
Carbon, max.	0.030
Manganese	2.00–3.00
Phosphorus, max.	0.040
Sulfur, max.	0.020
Silicon, max	1.00
Chromium	20.5–23.5
Nickel	1.00–2.00
Molybdenum	0.10–1.00
Nitrogen	0.15–0.27
Copper, max.	0.50
Iron	Balance

Table 2
Mechanical Property Requirements

Material	Tensile Strength, min.	Yield Strength, min. (0.2% Offset)	Elongation, min. (in 2 in. or 50 mm)
Sheet/strip $\leq \frac{3}{16}$ in. (≤ 5.0 mm)	101 ksi (700 MPa)	75 ksi (515 MPa)	30%
Plate $> \frac{3}{16}$ in. (> 5.0 mm)	95 ksi (655 MPa)	65 ksi (450 MPa)	30%
Tube	101 ksi (700 MPa)	75 ksi (515 MPa)	30%
Pipe	95 ksi (655 MPa)	65 ksi (450 MPa)	30%

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress Values, ksi [Note (1)]			
	Sheet	Plate	Pipe and Tube Wall Thickness $\leq \frac{3}{16}$ in.	Pipe and Tube Wall Thickness $> \frac{3}{16}$ in.
100	28.9	27.1	28.9	27.1
200	28.4	26.8	28.4	26.8
300	26.5	25.0	26.5	25.0
400	26.0	24.4	26.0	24.4
500	26.0	24.4	26.0	24.4
600	26.0	24.4	26.0	24.4
650	26.0	24.4	26.0	24.4

NOTE: (1) The criterion of 3.5 on tensile strength was used in establishing the values.

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress Values, MPa [Note (1)]			
	Sheet	Plate	Pipe and Tube Wall Thickness ≤ 5.00 mm	Pipe and Tube Wall Thickness > 5.00 mm
40	199	187	199	187
65	199	187	199	187
100	194	183	194	183
150	183	172	183	172
200	179	168	179	168
250	179	168	179	168
300	179	168	179	168
325	179	168	179	168
350 [Note (2)]	179	168	179	168

PRECAUTIONARY NOTE: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See paras. A-340 and A-360 in Appendix A of Section II, Part D.

NOTES:

- (1) The criterion of 3.5 on tensile strength was used in establishing the values.
 (2) The value at 350°C is for interpolation only. The maximum use temperature is 343°C.

Table 4
Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Strength, ksi			
	Sheet	Plate	Pipe and Tube Wall Thickness $\leq \frac{3}{16}$ in.	Pipe and Tube Wall Thickness $> \frac{3}{16}$ in.
100	101.0	95.0	101.0	95.0
200	99.5	93.6	99.5	93.6
300	92.9	87.4	92.9	87.4
400	90.9	85.5	90.9	85.5
500	90.9	85.5	90.9	85.5
600	90.9	85.5	90.9	85.5
650	90.9	85.5	90.9	85.5
700	90.9	85.5	90.9	85.5
750	90.9	85.5	90.9	85.5
800	90.2	84.8	90.2	84.8
850	88.6	83.4	88.6	83.4
900	88.3	83.1	88.3	83.1
950	88.3	83.1	88.3	83.1
1000	88.3	83.1	88.3	83.1

Table 4M
Tensile Strength Values

For Metal Temperature Not Exceeding, °C	Strength, MPa			
	Sheet	Plate	Pipe and Tube Wall Thickness ≤ 5.00 mm	Pipe and Tube Wall Thickness > 5.00 mm
40	696	655	696	655
65	696	655	696	655
100	679	639	679	639
150	656	617	656	617
200	640	602	640	602
250	630	593	630	593
300	627	590	627	590
325	627	590	627	590
350	627	590	627	590
375	627	590	627	590
400	627	590	627	590
425	622	585	622	585
450	612	576	612	576
475	608	572	608	572
500	608	572	608	572
525	608	572	608	572
550	608	572	608	572

**Table 5
Yield Strength Values**

For Metal Temperature Not Exceeding, °F	Strength, ksi			
	Sheet	Plate	Pipe and Tube Wall Thickness ≤ ³ / ₁₆ in.	Pipe and Tube Wall Thickness > ³ / ₁₆ in.
100	75.0	65.0	75.0	65.0
200	64.4	55.9	64.4	55.9
300	58.1	50.4	58.1	50.4
400	54.1	46.9	54.1	46.9
500	51.9	45.0	51.9	45.0
600	50.4	43.7	50.4	43.7
650	49.6	43.0	49.6	43.0
700	48.6	42.1	48.6	42.1
750	47.3	41.0	47.3	41.0
800	45.7	39.6	45.7	39.6
850	44.1	38.2	44.1	38.2
900	42.5	36.9	42.5	36.9
950	41.4	35.9	41.4	35.9
1000	41.1	35.7	41.1	35.7

**Table 5M
Yield Strength Values**

For Metal Temperature Not Exceeding, °C	Strength, MPa			
	Sheet	Plate	Pipe and Tube Wall Thickness ≤5.00 mm	Pipe and Tube Wall Thickness >5.00 mm
40	517	448	517	448
65	472	409	472	409
100	438	380	438	380
150	400	346	400	346
200	375	325	375	325
250	360	312	360	312
300	350	304	350	304
325	346	300	346	300
350	340	295	340	295
375	334	289	334	289
400	325	282	325	282
425	316	274	316	274
450	306	265	306	265
475	296	256	296	256
500	288	249	288	249
525	283	246	283	246
550	283	246	283	246

Case 2736-2

7% Ni Thermo-Mechanical Control Processed Steel Plate for Cryogenic Applications

Section VIII, Division 1

Approval Date: June 23, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May thermomechanical control processed (TMCP) 7% Ni-steel plates, meeting the requirements of ASTM A841/A841M-13, Grade G, Class 9 be used for welded construction under the rules of Section VIII, Division 1, Part ULT?

Reply: It is the opinion of the Committee that TMCP 7% Ni-steel plates, meeting the requirements of ASTM A841/A841M-13, Grade G, Class 9 may be used for welded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The maximum permitted nominal thickness of plates is 2 in. (50 mm).

(b) For Section VIII, Division 1, the rules of Subsection C, Part ULT shall apply.

(c) The material-specific requirements shall be those for 9% Ni-steel plate, SA-553 Type I, except that the allowable stress values in Tables 2 and 2M of this Case shall be used rather than those in Table ULT-23.

(d) For external pressure, Fig. CS-3 of Section II, Part D, Subpart 3 shall apply.

(e) The yield strength and tensile strength values for use in design shall be as shown in Tables 1 and 1M.

(f) The maximum allowable stress values for the material shall be those given in Tables 2 and 2M. Welded construction allowable stresses apply only to butt joints.

(g) The maximum design temperature shall be 150°F (65°C).

(h) Separate welding procedure and performance qualifications in accordance with Section IX shall be required for this material.

(i) The minimum tensile strength of the reduced tension specimen in accordance with QW-462.1 shall not be less than 100 ksi (690 MPa) or 95 ksi (655 MPa), respectively, at room temperature. The choice of UTS depends on the welding process and filler metal used in the construction.¹

(j) During fabrication and assembly, other than during welding, the material shall not be exposed to temperatures exceeding the final tempering temperature of 985°F (530°C).

(k) This Case number shall be shown on the Manufacturer's Data Report.

¹ Some nickel-base AWS classification consumables that will usually meet the 100 ksi (690 MPa) or 95 ksi (655 MPa) tensile strength requirements are: F43, SFA-5.11, ENiCrMo-3, UNS W86112; F43, SFA-5.14, ERNiCrMo-3, UNS N96625; F43, SFA-5.11, ENiCrMo-4, UNS W80276; and F43, SFA-5.14, ERNiCrMo-4, UNS N10276.

Table 1
Yield and Tensile Strength Values

Metal Temperature, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
-320	129	152
-300	122	143
-250	111	131
-200	106	124
-150	102	120
-100	97.4	115
-50	92.8	109
-20 to 100	85.0	100
150	81.8	100

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures other than room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require testing for yield strength of production material at temperatures other than at room temperature for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some test results at temperatures other than at room temperature on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require testing for tensile strength at temperatures other than at room temperature of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some test results at temperatures other than room temperature on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 1M
Yield and Tensile Strength Values

Metal Temperature, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
-195	886	1040
-170	793	933
-145	747	879
-120	719	846
-95	695	817
-70	668	786
-45	640	753
-30 to 40	586	690
65	562	690

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures other than room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require testing for yield strength of production material at temperatures other than at room temperature for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some test results at temperatures other than at room temperature on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require testing for tensile strength at temperatures other than at room temperature of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some test results at temperatures other than room temperature on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 2
Maximum Allowable Stress Values in Tension for Welded and Nonwelded Construction

Temperature, °F	Nonwelded Construction, ksi	Welded Construction	
		UTS, 100 ksi	UTS, 95 ksi
-320	43.3	38.9	36.9
-300	40.9	37.9	36.1
-250	37.3	36.3	34.6
-200	35.5	35.0	33.3
-150	34.2	33.5	31.8
-100	32.7	32.1	30.5
-50	31.2	31.0	29.5
-20 to 100	28.6	28.6	27.1
150	28.6	28.6	27.1

GENERAL NOTE: Allowable stresses for welded construction below 20°F (30°C) are based on trend curves for high-Ni welding consumables. These values are the same as those in Table ULT-23 for 5%, 8%, and 9% Ni-steels. Allowable stresses for nonwelded construction and for welded construction at 20°F (30°C) and above are based on trend curves for the base metal and use the criteria of Appendix 1 of Section II, Part D, except that the 1.1 factor on the tensile strength trend curve is not used for values below RT. Values at intermediate temperatures may be calculated by linear interpolation.

Table 2M
Maximum Allowable Stress Values in Tension for Welded and Nonwelded Construction

Temperature, °C	Nonwelded Construction, MPa	Welded Construction	
		UTS, 690 MPa	UTS, 655 MPa
-195	298	268	254
-170	267	255	243
-145	251	247	235
-120	242	238	226
-95	234	229	217
-70	225	220	210
-45	215	214	203
-30 to 40	197	197	187
65	197	197	187

GENERAL NOTE: Allowable stresses for welded construction below 20°F (30°C) are based on trend curves for high-Ni welding consumables. These values are the same as those in Table ULT-23 for 5%, 8%, and 9% Ni-steels. Allowable stresses for nonwelded construction and for welded construction at 20°F (30°C) and above are based on trend curves for the base metal and use the criteria of Appendix 1 of Section II, Part D, except that the 1.1 factor on the tensile strength trend curve is not used for values below RT. Values at intermediate temperatures may be calculated by linear interpolation.

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Case 2737-2

7% Ni Thermo-Mechanical Control Processed Steel Plate for Cryogenic Applications for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May thermo-mechanical control processed (TMCP) 7% Ni-steel plates, conforming to the chemical requirements listed in [Table 1](#), the mechanical properties listed in [Table 2](#), and otherwise conforming to the requirements of SA-841 be used for welded construction under the rules of Section VIII, Division 2, Class 2?

Reply: It is the opinion of the Committee that TMCP 7% Ni-steel plates, conforming to the chemical requirements listed in [Table 1](#),¹ the mechanical properties listed in [Table 2](#), and otherwise conforming to the requirements of SA-841 may be used for welded construction under the rules of Section VIII, Division 2, Class 2 provided the following additional requirements are met:

(a) The maximum permitted nominal thickness of plates is 2 in. (50 mm).

(b) For external pressure, Fig. CS-3 of Section II, Part D, Subpart 3 shall apply.

(c) The yield strength and tensile strength values for use in design shall be as shown in [Tables 3](#) and [3M](#).

(d) The maximum allowable stress values for the material shall be those given in [Tables 4](#) and [4M](#). Welded construction allowable stresses apply only to butt joints. The maximum design temperature shall be 150°F (65°C).

(e) Moduli of elasticity values shall be those listed in Section II, Part D, Subpart 2, Table TM-1 for Group F.

(f) Mean linear thermal expansion coefficients are as given in [Tables 5](#) and [5M](#).

(g) Nominal coefficients of thermal conductivity and thermal diffusivity are as given in [Tables 6](#) and [6M](#), and [7](#) and [7M](#), respectively.

(h) Poisson's ratio is 0.34.

(i) The density is 0.285 lb/in.³ (7 900 kg/m³).

(j) Separate welding procedure and performance qualifications in accordance with Section IX shall be required for this material.

(k) The minimum tensile strength at room temperature of the reduced tension specimen in accordance with QW-462.1 shall not be less than 100 ksi (690 MPa).²

(l) The weld metals for welding this base material shall have one of the following:

(1) a specified minimum yield strength of 62.5 ksi (431 MPa).

(2) one all weld-metal tension test specimen from each lot of consumable shall be tested to determine that the room-temperature yield strength meets 62.5 ksi (431 MPa) minimum. The test specimen shall conform to the dimensional standards of SFA-5.11, para. 12.1.

(m) The material is exempt from production impact tests of the weld metal in accordance with para. 6.6.5.2(b) of Division 2, Class 2.

(n) During fabrication and assembly, other than during welding, the material shall not be exposed to temperatures exceeding 985°F (530°C).

(o) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

¹ This material is susceptible to magnetization. Use of magnets in handling after heat treatment should be avoided if residual magnetism would be detrimental to subsequent fabrication or service.

² Some nickel-base AWS classification consumables that will usually meet the 100 ksi (690 MPa) or 95 ksi (655 MPa) tensile strength requirements are: F43, SFA-5.11, ENiCrMo-3, UNS W86112; F43, SFA-5.14, ERNiCrMo-3, UNS N96625; F43, SFA-5.11, ENiCrMo-4, UNS W80276; and F43, SFA-5.14, ERNiCrMo-4, UNS N10276.

Table 1
Chemical Requirements (Heat and Product)

Element	Weight, %
Carbon, max.	0.13
Silicon	0.04–0.25 [Note (1)]
Manganese	0.60–1.20
Phosphorus, max.	0.015
Sulfur, max.	0.015
Nickel	6.0–7.5
Chromium	0.30–1.00
Molybdenum, max.	0.30
Aluminum, acid sol., min.	0.008 [Note (1)]

NOTE: (1) Silicon may be less than 0.04%, provided that soluble aluminum is 0.025% or over.

Table 2
Mechanical Property Requirements

Property	Class 9
Tensile Strength, min., ksi (MPa)	100–120 (690–825)
Yield Strength, 0.2%, min., ksi (MPa)	85 (585)
Elongation in 2 in. (50 mm), %	20

Table 3
Yield and Tensile Strength Values

Metal Temperature, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
-320	129	152
-300	122	143
-250	111	131
-200	106	124
-150	102	120
-100	97.4	115
-50	92.8	109
-20 to 100	85.0	100
150	81.8	100

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures other than room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 2 require testing for yield strength of production material for use in Code components at temperatures other than room temperature. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some test results at temperatures other than room temperature on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures other than room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 2 require testing for tensile strength, at temperatures other than room temperature, of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some test results at temperatures other than room temperature on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 3M
Yield and Tensile Strength Values

Metal Temperature, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
-195	886	1040
-170	793	933
-145	747	879
-120	719	846
-95	695	817
-70	668	786
-45	640	753
-30 to 40	586	690
65	562	690

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures other than room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 2 require testing for yield strength of production material for use in Code components at temperatures other than room temperature. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some test results at temperatures other than room temperature on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures other than room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 2 require testing for tensile strength, at temperatures other than room temperature, of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some test results at temperatures other than room temperature on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 4
Maximum Allowable Stress Values in Tension for Welded and Nonwelded Construction

Temperature, °F	ksi
-20 to 100	41.7
150	41.7

GENERAL NOTE:
Maximum allowable stress values for 100°F may be used at temperatures down to -325°F.

Table 4M
Maximum Allowable Stress Values in Tension for Welded and Nonwelded Construction

Temperature, °C	MPa
-35 to 40	287
65	287

GENERAL NOTE:
Maximum allowable stress values for 40°C may be used at temperatures down to -200°C.

Table 5
Mean Linear Thermal Expansion Coefficients

Temperature Range, °F	Coefficient, in./in./°F
-320 to RT	2.8×10^{-6}
-300 to RT	3.0×10^{-6}
-250 to RT	3.4×10^{-6}
-200 to RT	3.9×10^{-6}
-150 to RT	4.3×10^{-6}
-100 to RT	4.8×10^{-6}
-50 to RT	5.2×10^{-6}
0 to RT	5.7×10^{-6}
RT to 100	6.6×10^{-6}
RT to 150	7.0×10^{-6}

Table 5M
Mean Linear Thermal Expansion Coefficients

Temperature Range, °C	Coefficient, in./in./°C
-196 to RT	5.0×10^{-6}
-170 to RT	5.7×10^{-6}
-150 to RT	6.3×10^{-6}
-100 to RT	7.8×10^{-6}
-50 to RT	9.2×10^{-6}
0 to RT	10.7×10^{-6}
RT to 20	11.3×10^{-6}
RT to 150	12.2×10^{-6}

Table 6
Thermal Conductivity Coefficients

Temperature, °F	Coefficient, Btu/hr-ft-°F
-320	12.6
-300	12.9
-250	13.6
-200	14.3
-150	15.0
-100	15.7
-50	16.4
0	17.1
20	17.4
70	18.1

Table 6M
Thermal Conductivity Coefficients

Temperature, °C	Coefficient, W/m-°C
-200	22.2
-150	24.3
-100	26.4
-50	28.5
0	30.5
20	31.4
50	32.6

Table 7
Thermal Diffusivity Coefficients

Temperature, °F	Coefficient, ft ² /hr
-320	0.346
-300	0.345
-250	0.344
-200	0.343
-150	0.343
-100	0.342
-50	0.341
0	0.340
20	0.339
70	0.339

Table 7M
Thermal Diffusivity Coefficients

Temperature, °C	Coefficient, × 10 ⁻⁶ m ² /sec
-200	7.8
-150	8.0
-100	8.2
-50	8.4
0	8.6
20	8.7
50	8.8

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Case 2738

Manufacturer's Data Reports

Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3

Approval Date: September 25, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible for Inspectors to only include their National Board Commission number on Manufacturer's Data Reports in lieu of their National Board

Commission Number and/or Jurisdiction Number as included in the Notes to completion of Manufacturer's Data Reports?

Reply: It is the opinion of the Committee that it is permissible for Inspectors to include only their National Board Commission Number regardless of the registration status of the pressure vessel or part.

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Case 2739

Alternative Diameter-To-Thickness Ratios for Spherical and Formed Heads With Openings

Section VIII, Division 2

Approval Date: September 25, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible to use the rules of Section VIII, Division 2 for openings in spherical and formed heads with diameter-to-thickness (D/T) ratios greater than the limit of 400, as defined in para. 4.5.2.1?

Reply: It is the opinion of the Committee that the rules of para. 4.5 may be used for any ratio of D/T under the following conditions:

(a) The opening satisfies all other requirements of para. 4.5.

(b) The nozzle is one of the following:

(1) a radial nozzle located in a spherical shell or formed head designed in accordance with the rules of para. 4.5.10

(2) a hillside or perpendicular nozzle in a formed head designed in accordance with the rules of para. 4.5.11

(c) This Case number shall be identified in the Manufacturer's Data Report.

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Case 2740-1

25Cr-7Ni-4Mo-N (UNS S32750) Austenitic-Ferritic Stainless Steel for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 25Cr-7Ni-4Mo-N (UNS S32750) Type 2507, austenitic-ferritic stainless steel products conforming to the specifications in [Table 1](#) be used for welded construction under the rules of Section VIII, Division 2, Class 2?

Reply: It is the opinion of the Committee that the materials described in the Inquiry may be used in the construction of welded pressure vessels conforming to the rules of Section VIII, Division 2, Class 2, provided the following additional requirements are met:

(a) The design temperature shall not exceed 600°F (316°C).

(b) The maximum wall thickness for tube and pipe shall be 1 in. (25 mm).

(c) The maximum allowable stress values shall be as given in [Tables 2](#) and [2M](#).

(d) For external pressure design, Fig. HA-5 of Section II, Part D shall be used.

(e) These materials shall be considered as P-No. 10H, Group 1.

(f) For physical properties, the material shall be considered as 25Cr-7Ni-4Mo-N material.

(g) Impact testing in accordance with the rules in para. 3.11.4 for austenitic-ferritic duplex stainless steels is required.

(h) Heat treatment after forming or fabrication is neither required nor prohibited, but when heat treatment is performed, it shall be performed from 1,880°F to 2,060°F (1025°C to 1125°C) followed by liquid quenching or rapid cooling by other means.

(i) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Product Specifications

Forgings (Type F53)	SA-182
Plate, sheet, and strip	SA-240
Seamless and welded pipe	SA-790
Seamless and welded tube	SA-789

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
100	48.3
150	48.3
200	47.2
250	45.1
300	43.3
350	41.7
400	40.4
450	39.4
500	38.6
550	38.3
600	38.3

GENERAL NOTE: This material may be expected to develop embrittlement after service at moderately elevated temperature; see Section II, Part D, Appendix A, A-340 and A-360.

NOTE: (1) For SA-789 welded tube and SA-790 welded pipe, a factor of 0.85 shall apply.

Table 2M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
40	333
65	333
100	322
125	310
150	299
175	289
200	280
225	273
250	268
275	265
300	263
325	263 [Note (2)]

GENERAL NOTE: This material may be expected to develop embrittlement after service at moderately elevated temperature; see Section II, Part D, Appendix A, A-340 and A-360.

NOTES:

- (1) For SA-789 welded tube and SA-790 welded pipe, a factor of 0.85 shall apply.
- (2) The maximum design temperature is 316°C; 325°C value is provided for interpolation only.

Case 2741

PW-39.2.1, PWHT Requirements for P-No. 4 Material Welded to Lower P-Number Material

Section I

Approval Date: August 15, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Changes have been approved for publication in the 2013 Edition of Section I to PW-39.2.1 to allow a reduced PWHT temperature when welding P-No. 4 material to a lower P-Number material. May those changes be applied ahead of publication of the 2013 Edition?

Reply: It is the opinion of the Committee that the changes approved for publication in the 2013 Edition of Section I to PW-39.2.1 to allow a reduced PWHT temperature when welding P-No. 4 material to a lower P-No. material may be applied ahead of publication of the 2013 Edition, provided the following requirements are met:

(a) Fillet welds, partial-penetration welds, and full-penetration welds through the tube or pipe thickness, attaching P-No. 4 tube and pipe to headers of lower P-Number material, may be postweld heat-treated at the temperature specified in Table PW-39 for the lower P-Number material, provided the tubes or pipe comply with all the following conditions:

- (1) maximum specified chromium content of 3.0%
- (2) maximum size of NPS 4 (DN 100)
- (3) maximum thickness of $\frac{1}{2}$ in. (13 mm)
- (4) maximum specified carbon content of not more than 0.15%

(b) This Case number shall be shown on the Manufacturer's Data Report.

(c) This Case shall be annulled six months after publication of the Code revisions.

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Case 2742

Composite Class III Pressure Vessel Lower Cycle Pressure Limit

Section X

Approval Date: August 29, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the lower pressure limit for cycle testing per para. 8-700.5.4.1 be increased?

Reply: It is the opinion of the Committee that the lower pressure limit for cycle testing of Section X, Class III vessels per para. 8-700.5.4.1 may be increased under the following conditions:

(a) If a minimum operating pressure is specified in the User Design Specification (UDS) that is greater than 10% of the design pressure, the vessels may be cycled between the minimum operating pressure and the design pressure, rather than between 10% of design pressure and the design pressure, for N pressure cycles as defined in para. 8-700.5.4.1. The number of full range startup/shutdown cycles shall also be addressed in the UDS, with pressure cycling between 10% of design pressure and the design pressure conducted accordingly.

(b) The minimum operating pressure shall be included on the nameplate in accordance with Part RS of Section X.

(c) This Case number shall be shown on the Fabricator's Data Report.

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Case 2743

Composite Class III Pressure Vessel Batch Cycle Testing

Section X

Approval Date: August 29, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may batch cycle testing be decreased once it is established that the pressure vessel design and materials are not sensitive to fatigue cycling?

Reply: It is the opinion of the Committee that the batch cycle testing for Section X, Class III vessels may be decreased once it is established that the pressure vessel design and materials are not sensitive to fatigue cycling under the following conditions:

(a) For the batch cycling test per para. 8-700.3, the number of cycles to be demonstrated per para. 8-700.5.4 may consider the number of fatigue tests, n ,

to include prior to qualification and batch tests of the same configuration.

(b) The batch cycling test per para. 8-700.3 is no longer required on every batch once it has been demonstrated that the pressure vessel design and materials are not sensitive to fatigue cycling by passing the batch cycle testing on a total of five vessels with the number of cycles per para. 8-700.5.4 and having no leaks either in the first set of N cycles, or in the second set of N cycles (where a leak would otherwise be allowed but not a rupture) for a total of 5.2 times the design service life. However, the batch cycle test must be repeated at least once every 3 yr. If a leak or rupture occurs during a batch test, then batch testing would have to be reinitiated until a new total of five vessels passes the cycle requirements per para. 8-700.5.4 with no leaks.

(c) This Case number shall be shown on the Fabricator's Data Report.

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Case 2744

Composite Pressure Vessel Analysis

Section X

Approval Date: August 29, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may mean (average) composite thickness and material properties be used for stress analysis under Section X, para. 8-400.1 rather than minimum thickness and material properties?

Reply: It is the opinion of the Committee that mean (average) composite thickness and material properties shall be used for stress analysis when the allowable strength for the laminate has been based on analysis using mean properties. Analysis using mean properties shall be used to determine the minimum thickness required for components.

This Case number shall be shown on the Fabricator's Data Report.

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Case 2745-1

Composite Pressure Vessels for High-Pressure Fluids

Section X

Approval Date: July 29, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may fluids other than hydrogen gas be contained in composite pressure vessels designed and constructed under the rules of Section X for Class III vessels with nonload-sharing liners?

Reply: It is the opinion of the Committee that composite pressure vessels with nonload-sharing liners and containing fluids other than compressed hydrogen may be designed and constructed under the rules of Section X, Mandatory Appendix 8, provided the following requirements are met:

(a) Additional fluids allowed are methane, natural gas, helium, nitrogen, water, and hydraulic oils. Use of mixtures of these fluids is permitted. Air is allowed to a maximum design pressure of 3,600 psi (24.8 MPa) and not permitted to mix with hydrocarbons or hydrogen. The maximum operating temperature with air shall be lower than 100°F below the auto-ignition temperature of the liner material at the design pressure, but no greater than the maximum allowed per this Code (see Mandatory Appendix 8, para. 8-400.3). The tank shall

be protected against gunfire. A penetration test in accordance with para. 8-700.5.10 must be run with the contained gas (air). The tank shall be protected from impacts in service. In addition, air shall be filtered for particles before being put in the vessel. The User is responsible for specifying the contained fluids in the Design Specification.

(b) Contained fluids shall be compatible with the composite, liner, and nozzle materials. If compatibility is not already demonstrated, testing must be conducted to confirm compatibility. Confirmation of compatibility shall be reported in the Fabricator's Data Report.

(c) Allowed permeation rates shall be included in the User Design Specification. The fabricator shall confirm permeation rate through testing.

(d) Permeation testing may be conducted with the fluid to be contained, or by using an alternate fluid with adjustment in rate made by considering relative molecular weight or by using relative viscosity, as appropriate.

(e) Additional pressure and bending loads present due to containment of liquids shall be considered in the stress analysis, and changes made to test pressures or procedures as appropriate during qualification testing to accurately assess the maximum design stresses.

(f) This Case number shall be shown on the Fabricator's Data Report.

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Case 2746

Composite Pressure Vessel Pressurization Rate

Section X

Approval Date: August 29, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the pressurization rate be increased for burst testing per para. 8-700.5.3.1?

Reply: It is the opinion of the Committee that the pressurization rate may be increased for burst testing per para. 8-700.5.3.1 under the following conditions:

(a) The pressurization rate shall not exceed 200 psi/sec (14 bar/s).

(b) If the pressurization rate exceeds 50 psi/sec (3.5 bar/s) at pressures above 80% of the design burst, either the vessel shall be located between the pressure source and the pressure measurement device, or the test pressure shall be held at the vessel's design burst pressure for 5 sec prior to resuming the test.

(c) This Case number shall be shown on the Fabricator's Data Report.

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Case 2747

Composite Pressure Vessel Nozzle Design Change

Section X

Approval Date: August 29, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May a change be made to the nozzle design without conducting a creep test as indicated in Table 8-700.2.1-1?

Reply: It is the opinion of the Committee that for new vessel construction, a change to the nozzle design will not change the creep characteristics of the liner or resin, and therefore, a creep test shall not be required, as follows:

(a) A creep test per para. 8-700.5.5 shall not be required for a change to the design of the end nozzle.

(b) This Case number shall be shown on the Fabricator's Data Report.

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Case 2748-2

Use of SA/EN 10028-2, Grade 20MnMoNi4-5, Quenched and Tempered Steel Plate for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may steel plates manufactured in accordance with SA/EN 10028-2, Grade 20MnMoNi4-5 be used in Section VIII, Division 2, Class 2 construction?

Reply: It is the opinion of the Committee that steel plates manufactured in accordance with SA/EN 10028-2, Grade 20MnMoNi4-5 be used in Section VIII, Division 2, Class 2 construction, provided the following additional requirements are met:

(a) The design temperature shall not exceed 750°F (399°C).

(b) For the purpose of impact test requirements, this material shall be considered Curve C material in Figures 3.7, 3.7M, 3.8, and 3.8M of Section VIII, Division 2, Class 2.

(c) Limits on trace elements shall be those specified in Table 1 of SA-20/SA-20M.

(d) The maximum allowable stress values shall be those listed in [Tables 1](#) and [1M](#).

(e) The yield and tensile strengths shall be as shown in [Tables 2](#) and [2M](#), and [Tables 3](#) and [3M](#), respectively.

(f) For physical properties, the material shall be considered Mn-0.5Mo-0.5Ni material.

(g) For external pressure design, the requirements of Figure CS-5 of Section II, Part D shall apply.

(h) This material shall be considered P-No. 3, Group 3.

(i) This material shall be considered Table 3-A.1 material.

(j) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi, for Thickness, <i>t</i> , in.				
	<i>t</i> ≤ 1.5	1.5 < <i>t</i> ≤ 2.5	2.5 < <i>t</i> ≤ 4	4 < <i>t</i> ≤ 6	6 < <i>t</i> ≤ 10
100	35.7	35.7	34.4	34.4	33.8
150	35.7	35.7	34.4	34.4	33.8
200	35.7	35.7	34.4	34.4	33.8
250	35.7	35.7	34.4	34.4	33.8
300	35.7	35.7	34.4	34.4	33.8
350	35.7	35.7	34.4	34.4	33.8
400	35.7	35.7	34.4	34.4	33.8
450	35.7	35.7	34.4	34.4	33.8
500	35.7	35.7	34.4	34.4	33.3
550	35.7	35.7	34.4	34.4	32.9
600	35.7	35.7	34.4	34.4	32.5
650	35.7	35.7	34.4	34.4	32.1
700	35.7	35.7	34.4	34.4	31.5
750	35.7	35.4	34.4	33.9	30.8

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa, for Thickness, <i>t</i> , mm				
	<i>t</i> ≤ 40	40 < <i>t</i> ≤ 60	60 < <i>t</i> ≤ 100	100 < <i>t</i> ≤ 150	150 < <i>t</i> ≤ 250
40	246	246	238	238	233
65	246	246	238	238	233
100	246	246	238	238	233
125	246	246	238	238	233
150	246	246	238	238	233
175	246	246	238	238	233
200	246	246	238	238	233
225	246	246	238	238	233
250	246	246	238	238	231
275	246	246	238	238	228
300	246	246	238	238	226
325	246	246	238	238	223
350	246	246	238	238	220
375	246	246	238	238	217
400 [Note (1)]	246	244	238	233	212

NOTE: (1) The maximum design temperature is 399°C; 400°C values are provided for interpolation only.

Table 2
Yield Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength Values, ksi, for Thickness, <i>t</i> , in.				
	$t \leq 1.5$	$1.5 < t \leq 2.5$	$2.5 < t \leq 4$	$4 < t \leq 6$	$6 < t \leq 10$
100	68.2	66.7	65.3	63.8	58.0
150	65.8	64.4	63.0	61.6	56.0
200	64.4	63.0	61.7	60.3	54.8
250	63.1	61.8	60.5	59.1	53.7
300	62.0	60.7	59.4	58.1	52.8
350	61.0	59.7	58.4	57.1	51.9
400	60.2	58.9	57.6	56.3	51.2
450	59.5	58.2	56.9	55.7	50.6
500	58.7	57.5	56.2	55.0	50.0
550	58.1	56.8	55.6	54.3	49.4
600	57.4	56.1	54.9	53.7	48.8
650	56.6	55.4	54.2	53.0	48.1
700	55.6	54.4	53.2	52.0	47.3
750	54.3	53.2	52.0	50.8	46.2

GENERAL NOTE: The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average” as these terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 2 require elevated temperature testing for yield strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 2M
Yield Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength Values, MPa, for Thickness, <i>t</i> , mm				
	<i>t</i> ≤ 40	40 < <i>t</i> ≤ 60	60 < <i>t</i> ≤ 100	100 < <i>t</i> ≤ 150	150 < <i>t</i> ≤ 250
40	470	460	450	440	400
65	454	444	434	425	386
100	442	432	423	414	376
125	434	425	416	407	370
150	427	418	409	400	364
175	421	412	403	394	358
200	416	407	398	389	354
225	411	402	393	385	350
250	406	398	389	381	346
275	402	394	385	377	342
300	398	390	381	373	339
325	394	385	377	369	335
350	389	380	372	364	331
375	382	374	366	358	325
400 [Note (1)]	374	366	358	350	318

GENERAL NOTE: The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average” as these terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 2 require elevated temperature testing for yield strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

NOTE: (1) The maximum design temperature is 399°C; 400°C values are provided for interpolation only.

Table 3
Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Tensile Strength Values, ksi, for Thickness, <i>t</i> , in.				
	$t \leq 1.5$	$1.5 < t \leq 2.5$	$2.5 < t \leq 4$	$4 < t \leq 6$	$6 < t \leq 10$
100	85.6	85.6	82.7	82.7	81.2
150	85.6	85.6	82.7	82.7	81.2
200	85.6	85.6	82.7	82.7	81.2
250	85.6	85.6	82.7	82.7	81.2
300	85.6	85.6	82.7	82.7	81.2
350	85.6	85.6	82.7	82.7	81.2
400	85.6	85.6	82.7	82.7	81.2
450	85.6	85.6	82.7	82.7	81.2
500	85.6	85.6	82.7	82.7	81.2
550	85.6	85.6	82.7	82.7	81.2
600	85.6	85.6	82.7	82.7	81.2
650	85.6	85.6	82.7	82.7	81.2
700	85.6	85.6	82.7	82.7	81.2
750	85.6	85.6	82.7	82.7	81.2

GENERAL NOTE: The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to "average" as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 2 require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

**Table 3M
Tensile Strength Values**

For Metal Temperature Not Exceeding, °C	Tensile Strength Values, MPa, for Thickness, <i>t</i> , mm				
	<i>t</i> ≤ 40	40 < <i>t</i> ≤ 60	60 < <i>t</i> ≤ 100	100 < <i>t</i> ≤ 150	150 < <i>t</i> ≤ 250
40	590	590	570	570	560
65	590	590	570	570	560
100	590	590	570	570	560
125	590	590	570	570	560
150	590	590	570	570	560
175	590	590	570	570	560
200	590	590	570	570	560
225	590	590	570	570	560
250	590	590	570	570	560
275	590	590	570	570	560
300	590	590	570	570	560
325	590	590	570	570	560
350	590	590	570	570	560
375	590	590	570	570	560
400 [Note (1)]	590	590	570	570	560

GENERAL NOTE: The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 2 require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

NOTE: (1) The maximum design temperature is 399°C; 400°C values are provided for interpolation only.

Case 2749-2

Use of EN 10222-2:1999, Grade 18MnMoNi5-5, Steel Forgings for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may steel forgings, manufactured in accordance with EN 10222-2:1999, Grade 18MnMoNi5-5 be used in Section VIII, Division 2, Class 2 construction?

Reply: It is the opinion of the Committee that forgings, manufactured in accordance with EN 10222-2:1999,¹ Grade 18MnMoNi5-5 be used in Section VIII, Division 2, Class 2 construction, provided the following additional requirements are met:

(a) If resurfacing by welding is acceptable by agreement between the purchaser and the material producer, and in accordance with para. 8.2.3 of EN 10222-1, the following requirements must be fulfilled.

(1) Preparation for repair welding shall include inspection to assure complete removal of the defect.

(2) Repairs shall be made utilizing welding procedures, welders, and welding operators qualified in accordance with Section IX.

(b) The design temperature shall not exceed 750°F (399°C).

(c) For the purpose of impact test requirements, this material shall be considered Curve C material in Figures 3.7, 3.7M, 3.8, and 3.8M of Section VIII, Division 2, Class 2.

(d) Limits on trace elements shall be those specified in Table 1 of SA-20/SA-20M.

(e) The maximum allowable stress values shall be those listed in Tables 1 and 1M.

(f) The yield and tensile strengths shall be as shown in Tables 2 and 2M.

(g) For physical properties, the material shall be considered Mn-0.5Mo-0.5Ni material.

(h) For external pressure design, the requirements of Fig. CS-5 of Section II, Part D shall apply.

(i) This material shall be considered P-No. 3, Group 3.

(j) This material shall be considered Table 3-A.1 material.

(k) This Case number shall be marked on the material, documented on the material test report, and shown on the Manufacturer's Data Report.

¹ See Section II, Part A, Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10222-2:1999 and its references.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	33.2
150	33.2
200	33.2
250	33.2
300	33.2
350	33.2
400	33.2
450	33.2
500	33.2
550	32.9
600	32.5
650	32.1
700	31.5
750	30.8

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	229
65	229
100	229
125	229
150	229
175	229
200	229
225	229
250	229
275	228
300	226
325	223
350	220
375	217
400	212 [Note (1)]

NOTE: (1) The maximum design temperature is 399°C; 400°C value is provided for interpolation purposes only.

Table 2
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength Values, ksi [Note (1)]	Tensile Strength Values, ksi [Note (2)]
100	58.0	79.8
150	56.0	79.8
200	54.8	79.8
250	53.7	79.8
300	52.8	79.8
350	51.9	79.8
400	51.2	79.8
450	50.6	79.8
500	50.0	79.8
550	49.4	79.8
600	48.8	79.8
650	48.1	79.8
700	47.3	79.8
750	46.2	79.8

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average” as these terms are applied to a statistical treatment of a homogeneous set of data. Neither the Material Specification nor the rules of Section VIII, Division 2 require elevated temperature testing for yield strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the Material Specification nor the rules of Section VIII, Division 2 require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 2M
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength Values, MPa [Note (1)]	Tensile Strength Values, MPa [Note (2)]
40	400	550
65	386	550
100	376	550
125	370	550
150	364	550
175	358	550
200	354	550
225	350	550
250	346	550
275	342	550
300	339	550
325	335	550
350	331	550
375	325	550
400 [Note (3)]	318	550

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average” as these terms are applied to a statistical treatment of a homogeneous set of data. Neither the Material Specification nor the rules of Section VIII, Division 2 require elevated temperature testing for yield strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the Material Specification nor the rules of Section VIII, Division 2 require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (3) The maximum design temperature is 399°C; 400°C values are provided for interpolation purposes only

Case 2750

Thermo-Mechanical Control Processed 7% Ni Steel Plate

Section VIII, Division 1

Approval Date: December 12, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May thermo-mechanical control processed 7% Ni-steel plates, conforming to the chemical requirements listed in [Table 1](#), the mechanical properties listed in [Table 2](#), and otherwise conforming to the requirements of SA-841, be used for welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that thermo-mechanical control processed 7% Ni-steel plates, conforming to the chemical requirements listed in [Table 1](#),¹ the mechanical properties listed in [Table 2](#), and otherwise conforming to the requirements of SA-841 may be used for welded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The maximum permitted nominal thickness of plates is 2 in. (50 mm).

(b) The rules of Subsection C, Part UHT shall apply.

(c) For external pressure, Figure CS-3 of Section II, Part D shall apply.

(d) The yield strength and tensile strength values for use in design shall be those given in [Table 3](#) and [Table 3M](#).

(e) The maximum allowable stress values for the material shall be those given in [Table 4](#) and [Table 4M](#).

(f) The maximum design temperature shall be 150°F (65°C).

(g) Separate welding procedure and performance qualifications in accordance with Section IX shall be required for this material.

(h) During fabrication and assembly, other than during welding, the material shall not be exposed to temperatures exceeding the final tempering temperature of 985°F (530°C).

(i) This Case number shall be included in the marking and referenced in the documentation of the material and shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements (Heat and Product)

Element	Weight, %
Carbon, max.	0.13
Silicon	0.04–0.25 [Note (1)]
Manganese	0.60–1.20
Phosphorus, max.	0.015
Sulfur, max.	0.015
Nickel	6.0–7.5
Chromium	0.30–1.00
Molybdenum, max.	0.30
Aluminum, acid sol., min.	0.008 [Note (1)]

NOTE: (1) Silicon may be less than 0.04%, provided that soluble aluminum is 0.025% or over.

Table 2

Property	Class 9
Tensile Strength, min., ksi (MPa)	100–120 (690–825)
Yield Strength, 0.2%, min., ksi (MPa)	85 (585)
Elongation in 2 in. (50 mm), %	20

¹ This material is susceptible to magnetization. Use of magnets in handling after heat treatment should be avoided if residual magnetism would be detrimental to subsequent fabrication or service.

**Table 3
Yield and Tensile Strength Values**

Metal Temperature, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
-20 to 100	85.0	100
150	81.8	100

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require testing for yield strength of production material at temperatures above room temperature for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require testing for tensile strength of production material at temperatures above room temperature for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

**Table 3M
Yield and Tensile Strength Values**

Metal Temperature, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
-30 to 40	586	690
65	562	690

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require testing for yield strength of production material at temperatures above room temperature for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require testing for tensile strength of production material at temperatures above room temperature for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 4
Maximum Allowable Stress Values in Tension

Temperature, °F	ksi
-20 to 100	28.6
150	28.6

GENERAL NOTE: Allowable stresses for Part UHT construction are based on trend curves for the base metal and use the criteria of Appendix 1. Values at intermediate temperatures may be calculated by linear interpolation.

Table 4M
Maximum Allowable Stress Values in Tension

Temperature, °C	MPa
-30 to 40	197
65	197

GENERAL NOTE: Allowable stresses for Part UHT construction are based on trend curves for the base metal and use the criteria of Appendix 1. Values at intermediate temperatures may be calculated by linear interpolation.

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Case 2751

Alternative Rules for Hemispherical Head Attached to Cylindrical Shell Having Integral Backing Ring That Is Part of the Shell

Section VIII, Division 1

Approval Date: December 12, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions can a hemispherical head be attached to a cylindrical shell using an integral backing ring that is part of the shell?

Reply: It is the opinion of the Committee that a hemispherical head may be attached to a shell with an integral backing ring that is part of the shell, provided the following conditions are met:

(a) MAWP on the vessel shall not exceed 3,300 psig (22.8 MPa).

(b) Maximum design metal temperature shall not exceed 400°F (205°C).

(c) MDMT stamped on the nameplate shall not be colder than -20°F (-29°C).

(d) The minimum required thickness of the shell, t_{shell} , and head, t_{head} , as shown in [Figure 1](#), are per UG-27 and UG-32(f), respectively.

(e) Cyclic loading is not a controlling design requirement (UG-22).

(f) The vessel is not in lethal service (UW-2).

(g) The shell is machined to form an integral backing ring meeting the requirements of [Figure 1](#).

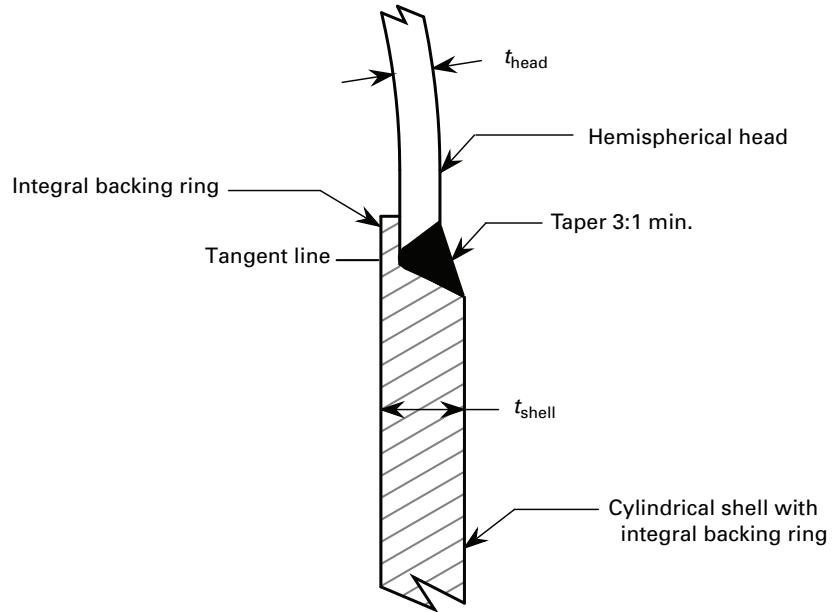
(h) The joint efficiency of the head-to-shell joint shall be 0.90 from Table UW-12 for a Type 2 joint based on full radiographic examination. The limitations in Table UW-12 for the Type 2 joints do not apply.

(i) Stress analysis of the head-to-shell joint shall be performed per the requirements of Section VIII, Division 2, Part 5, and the local membrane and local membrane plus bending stresses shall satisfy $1.0SE$ and $1.5SE$, respectively, where E is the joint efficiency, and S is the Section VIII, Division 1 allowable stress value.

(j) The weld attaching the shell to the head shall have full radiographic examination and meet the requirements of UW-51.

(k) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Alternative Hemispherical Head to Cylindrical Shell Weld Detail



Case 2752-1

22Cr-25Ni-3.5W-3Cu Austenitic Stainless Steel UNS S31035

Section VIII, Division 1

Approval Date: May 30, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed alloy UNS S31035 seamless pipe with the chemical composition conforming to Table 1, mechanical properties conforming to Table 2, and otherwise conforming to the respective requirements of the specification given in Table 3, and alloy UNS S31035 tubing conforming to SA-213/SA-213M and to Table 1 be used for welded construction up to 1,382°F (750°C) under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that solution annealed alloy UNS S31035 seamless pipe and tube as described in the Inquiry may be used in welded construction under the rules of Section VIII, Division 1, provided the following requirements are met:

(a) The material shall be heat treated at a temperature of 2,155°F to 2,280°F (1 180°C to 1 250°C) followed by rapid cooling in air or water.

(b) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UHA for austenitic stainless steels.

(c) For Section VIII, Division 1, the maximum allowable stress values for the material shall be those given in Table 4 and Table 4M. The yield strength values, $Y-1$, and tensile strength values, U , are given in Table 5 and Table 5M.

(d) Separate welding procedure qualification shall be conducted for the material in accordance with Section IX.

(e) For the purposes of performance qualification, the material shall be considered P-No. 45. Pressure-retaining welds of SA-213/SA-213M and seamless SA-312/SA-312M UNS S31035 tube and pipe shall be limited to circumferential butt welds in tube and pipe of 3½ in. (90 mm) O.D. and smaller. For circumferential butt welds of UNS S31035 to itself, filler metals shall be limited to nickel-based fillers SFA-5.11 class ENiCrFe-2, SFA-5.14 class ERNiCr-3, or SFA-5.14 class ERNiCrCoMo-1.

(f) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of para. (a) shall apply.

(g) For external pressure design, Figure HA-2 in Section II, Part D shall apply.

(h) The material is exempt from the grain size requirement in SA-213/SA-213M and SA-312/SA-312M.

(i) This Case number shall be shown on the documentation and marking of the material, and recorded on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition Limits, %
Carbon	0.04–0.10
Manganese, max.	0.60
Phosphorous, max.	0.025
Sulfur, max.	0.015
Silicon, max.	0.40
Chromium	21.5–23.5
Nickel	23.5–26.5
Tungsten	3.0–4.0
Cobalt	1.0–2.0
Copper	2.5–3.5
Niobium	0.40–0.60
Boron	0.002–0.008
Nitrogen	0.20–0.30

Table 2
Mechanical Test Requirements (Room Temperature)

Tensile Strength, min. ksi (MPa)	95 (655)
Yield Strength, 0.2% offset, min., ksi (MPa)	45 (310)
Elongation, in 2 in. (50 mm) min., %	40

Table 3
Product Specification

Seamless pipe	SA-312/SA-312M
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Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]
75	27.1	27.1
100	27.1	27.1
150	26.9	27.1
200	25.5	27.1
250	24.3	26.9
300	23.4	26.3
350	22.6	25.9
400	22.0	25.5
450	21.4	25.2
500	21.0	25.0
550	20.6	24.8
600	20.3	24.7
650	20.0	24.6
700	19.7	24.5
750	19.5	24.4
800	19.2	24.3
850	18.9	24.2
900	18.7	24.0
950	18.4	23.7
1,000	18.2	23.4
1,050	17.9	23.0
1,100	17.7	22.5
1,150	17.5	21.1 [Note (2)]
1,200	16.2 [Note (2)]	16.2 [Note (2)]
1,250	12.1 [Note (2)]	12.1 [Note (2)]
1,300	8.9 [Note (2)]	8.9 [Note (2)]
1,350	6.5 [Note (2)]	6.5 [Note (2)]
1,400	4.9 [Note (2)], [Note (3)]	4.9 [Note (2)], [Note (3)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These stress values are obtained from time-dependent properties.
- (3) These values are provided for interpolation purposes only. The maximum use temperature is 1,382°F.

Table 4M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Maximum Allowable, Stress Values, MPa [Note (1)]
40	184	184
65	184	184
100	174	184
125	167	184
150	161	181
175	156	179
200	152	176
225	149	174
250	146	173
275	143	172
300	141	171
325	139	170
350	138	170
375	136	169
400	134	168
425	133	168
450	131	167
475	129	166
500	128	164
525	126	163
550	125	160
575	123	158
600	122	154
625	120	140 [Note (2)]
650	111 [Note (2)]	111 [Note (2)]
675	85.1 [Note (2)]	85.1 [Note (2)]
700	64.4 [Note (2)]	64.4 [Note (2)]
725	48.5 [Note (2)]	48.5 [Note (2)]
750	37.1 [Note (2)]	37.1 [Note (2)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These stress values are obtained from time-dependent properties.

Table 5
Yield Strength, Y-1, Values and Tensile Strength, U, Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi	Tensile Strength, ksi
75	45.0	95.0
100	45.0	95.0
150	40.4	95.0
200	38.2	95.0
250	36.5	94.1
300	35.0	92.1
350	33.9	90.5
400	32.9	89.3
450	32.2	88.3
500	31.5	87.5
550	31.0	86.9
600	30.5	86.5
650	30.0	86.2
700	29.6	85.8
750	29.2	85.5
800	28.8	85.1
850	28.4	84.6
900	28.0	84.0
950	27.6	83.1
1,000	27.3	82.0
1,050	26.9	80.6
1,100	26.6	78.9
1,150	26.3	76.8
1,200	26.0	74.4
1,250	25.8	71.6
1,300	25.7	68.4
1,350	25.6	64.8
1,400	25.6 [Note (1)]	60.8 [Note (1)]

NOTE: (1) These values are provided for interpolation purposes only. The maximum use temperature is 1,382°F.

Table 5M
Yield Strength, Y-1, And Tensile Strength, U, Values

For Metal Temperature Not Exceeding, °C	Yield Yield Strength, MPa	Tensile Strength, MPa
40	310	655
65	279	655
100	260	655
125	250	647
150	241	635
175	234	625
200	228	617
225	223	610
250	219	605
275	215	601
300	212	598
325	209	595
350	206	593
375	204	591
400	201	589
425	199	587
450	196	584
475	194	580
500	192	575
525	189	569
550	187	561
575	185	552
600	183	540
625	181	527
650	179	512
675	178	495
700	177	475
725	176	453
750	176	429

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Case 2753-1

22Cr-25Ni-3.5W-3Cu Austenitic Stainless Steel UNS S31035

Section I

Approval Date: March 13, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed alloy UNS S31035 seamless pipe with the chemical composition conforming to Table 1, mechanical properties conforming to Table 2, and otherwise conforming to the respective requirements of the specification given in Table 3, and alloy UNS S31035 tubing conforming to SA-213/SA-213M and to Table 1 be used for welded construction up to 1,382°F (750°C) in steam-touched service under the rules of Section I?

Reply: It is the opinion of the Committee that solution annealed alloy UNS S31035 seamless pipe and tube as described in the Inquiry may be used in welded construction under the rules of Section I, provided the following requirements are met:

(a) The material shall be heat treated at a temperature of 2,155°F to 2,280°F (1 180°C to 1250°C) followed by rapid cooling in air or water.

(b) The maximum allowable stress values for the material shall be those given in Table 4 and Table 4M.

(c) The rules of PG-19 for 347H (UNS S34709) shall apply for this material except that solution treatment, when required, shall be per (a).

(d) Separate welding procedure qualification shall be conducted for the material in accordance with Section IX.

(e) For the purposes of performance qualification, the material shall be considered P-No. 45.

(f) Pressure retaining welds of SA-213/SA-213M and seamless SA-312/SA-312M UNS S31035 tube and pipe shall be limited to circumferential butt welds in tube and pipe of 3½ in. (89 mm) O.D. and smaller. For circumferential butt welds of UNS S31035 to itself, filler metals shall be limited to nickel-based fillers SFA-5.11 class ENiCrFe-2, SFA-5.14 class ERNiCr-3, or SFA-5.14 class ERNiCrCoMo-1.

(g) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of para. (a) shall apply.

(h) The *y*-factor for this material in PG-27.2 shall be the same as alloy 800H.

(i) The material is exempt from the grain size requirement in SA-213/SA-213M and SA-312/SA-312M.

(j) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition Limits, %
Carbon	0.04–0.10
Manganese, max.	0.60
Phosphorous, max.	0.025
Sulfur, max.	0.015
Silicon, max.	0.40
Chromium	21.5–23.5
Nickel	23.5–26.5
Tungsten	3.0–4.0
Cobalt	1.0–2.0
Copper	2.5–3.5
Niobium	0.40–0.60
Boron	0.002–0.008
Nitrogen	0.20–0.30

Table 2
Mechanical Test Requirements (Room Temperature)

Tensile Strength, min. ksi (MPa)	95 (655)
Yield Strength, 0.2% offset, min., ksi (MPa)	45 (310)
Elongation, in 2 in. (50 mm) min., %	40

Table 3
Product Specification

Seamless pipe	SA-312/SA-312M
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Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi
75	27.1	27.1
100	27.1	27.1
150	26.9	27.1 [Note (1)]
200	25.5	27.1 [Note (1)]
250	24.3	26.9 [Note (1)]
300	23.4	26.3 [Note (1)]
350	22.6	25.9 [Note (1)]
400	22.0	25.5 [Note (1)]
450	21.4	25.2 [Note (1)]
500	21.0	25.0 [Note (1)]
550	20.6	24.8 [Note (1)]
600	20.3	24.7 [Note (1)]
650	20.0	24.6 [Note (1)]
700	19.7	24.5 [Note (1)]
750	19.5	24.4 [Note (1)]
800	19.2	24.3 [Note (1)]
850	18.9	24.2 [Note (1)]
900	18.7	24.0 [Note (1)]
950	18.4	23.7 [Note (1)]
1,000	18.2	23.4 [Note (1)]
1,050	17.9	23.0 [Note (1)]
1,100	17.7	22.5 [Note (1)]
1,150	17.5	21.1 [Note (1)], [Note (2)]
1,200	16.2 [Note (2)]	16.2 [Note (2)]
1,250	12.1 [Note (2)]	12.1 [Note (2)]
1,300	8.9 [Note (2)]	8.9 [Note (2)]
1,350	6.5 [Note (2)]	6.5 [Note (2)]
1,400	4.9 [Note (2)], [Note (3)]	4.9 [Note (2)], [Note (3)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These stress values shown are obtained from time-dependent properties.
- (3) These values are provided for interpolation purposes only. The maximum use temperature is 1,382°F.

Table 4M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa
40	184	184
65	184	184
100	174	184 [Note (1)]
125	167	184 [Note (1)]
150	161	181 [Note (1)]
175	156	179 [Note (1)]
200	152	176 [Note (1)]
225	149	174 [Note (1)]
250	146	173 [Note (1)]
275	143	172 [Note (1)]
300	141	171 [Note (1)]
325	139	170 [Note (1)]
350	138	170 [Note (1)]
375	136	169 [Note (1)]
400	134	168 [Note (1)]
425	133	168 [Note (1)]
450	131	167 [Note (1)]
475	129	166 [Note (1)]
500	128	164 [Note (1)]
525	126	163 [Note (1)]
550	125	160 [Note (1)]
575	123	158 [Note (1)]
600	122	154 [Note (1)]
625	120	140 [Note (1)], [Note (2)]
650	111 [Note (2)]	111 [Note (2)]
675	85.1 [Note (2)]	85.1 [Note (2)]
700	64.4 [Note (2)]	64.4 [Note (2)]
725	48.5 [Note (2)]	48.5 [Note (2)]
750	37.1 [Note (2)]	37.1 [Note (2)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These stress values shown are obtained from time-dependent properties.

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Case 2754

Use of SA-193/SA-193M Grade B16 Bolting in Diameters Larger Than 7 in. (175 mm)

Section VIII, Division 1; Section VIII, Division 2

Approval Date: December 12, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-193/SA-193M Grade B16 bolting in diameters larger than 7 in. (175 mm) be used in Section VIII, Divisions 1 and 2 (2007 edition and later) construction?

Reply: It is the opinion of the Committee that SA-193/SA-193M Grade B16 bolting in diameters larger than 7 in. (175 mm) may be used in Section VIII, Divisions 1 and 2 (2007 edition and later) construction, provided the following additional requirements are met:

(a) The diameter of the bolting shall not exceed 8 in. (200 mm).

(b) The mechanical properties of the bolting shall meet the requirements of SA-193/SA-193M for Grade B16 for over M100 to M180 (over 4 in. to 8 in.), as applicable.

(c) All other requirements for SA-193/SA-193M Grade B16 shall be met.

(d) The design temperature shall not exceed the applicable limits in Section II, Part D.

(e) The allowable stresses shall be per Section II, Part D, Table 3 or 4 for SA-193/SA-193M Grade B16, $4 < t \leq 7$ in. ($100 < t \leq 175$ mm), as applicable.

(f) This Case number shall be marked on the material, documented on the material test report, and shown on the Manufacturer's Data Report.

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Case 2755

Exemption from Preheat and PWHT for Autogenous Buttwelding of SA-213/SA-213M T22 Seamless Tubing

Section I

Approval Date: December 18, 2012

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may autogenous buttwelds of SA-213/SA-213M T22 material be exempted from the preheat and PWHT requirements of PW-39?

Reply: It is the opinion of the Committee that autogenous buttwelds of SA-213/SA-213M T22 material may be considered exempt from the preheat and PWHT requirements of PW-39, provided the following requirements are met:

(a) The welding process shall be limited to automatic, autogenous GTAW.

(b) The tubing size shall be limited to a maximum O.D. of 1.5 in. (38 mm) and a thickness range of 0.095 in. to 0.165 in. (2.4 mm to 4.2 mm).

(c) The welding procedure shall use a multi-pass, staged process as follows:

(1) A minimum preheat of 60°F (16°C) shall be established prior to starting the arc for the first pass.

(2) The first weld pass shall use a lower heat input than the subsequent pass to raise the temperature in the welding zone to a minimum of 300°F (150°C) prior to welding the second pass.

(3) After completion of the first weld pass, a specified wait time shall be determined to limit the maximum interpass temperature but also to maintain the minimum preheat for the second weld pass.

(4) The heat input shall be sufficiently increased for the second weld pass to completely remelt the material fused during the first weld pass and to achieve penetration and fusion through the full thickness of the tubing.

(5) All temperature limits shall be verified.

(d) The weld procedure and performance qualifications shall be conducted as prescribed in Section IX and include the following:

(1) two separate weld samples, at the minimum and maximum tube O.D. range expected to be applied, must be completely tested.

(2) macrographs and micrographs shall be prepared to verify the complete remelt of the first weld, full penetration and fusion of the second weld pass.

(3) tension tests per QW-150.

(4) root and face guided-bend tests per QW-160.

(5) the interpass temperature shall be limited to 650°F (345°C) maximum.

(6) heat input parameters shall be established for each weld pass and the acceptable wait-time range between weld passes determined based on the measured cooling rate. The acceptable wait-time range between weld passes shall be included in the user's WPS.

(7) the final pass cool down rate shall be limited to ensure the weld cap hardness readings do not exceed 340 HV10 as follows:

(-a) Remove the weld head immediately after weld completion.

(-b) Apply a minimum of 2 in. (50 mm) thick x 6 in. (150 mm) long insulating sleeve, centered at the weld, for a minimum of 30 minutes.

(-c) After cool down, obtain a minimum of five equidistant hardness readings across the entire face of the weld.

(e) All of the welds shall be 100% examined by RT or UT with acceptance criteria per Section I. If UT examination is used, the written procedure shall conform to the requirements of Section V, Article 4, Mandatory Appendix VII.

(f) This Case number shall be identified in the Manufacturer's Data Report.

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Case 2756

57Ni-22Cr-14W-2Mo-La Alloy (UNS N06230) Autogenously Welded Tube and Seamless Pipe and Tube

Section I

Approval Date: January 7, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-annealed alloy UNS N06230 autogenously welded tube and seamless pipe and tube conforming to the specifications listed in [Table 1](#) be used in water service in welded construction for temperatures above 1,000°F (538°C) and up to 1,250°F (677°C) under Section I?

Reply: It is the opinion of the Committee that solution-annealed alloy UNS N06230 autogenously welded tube and seamless pipe and tube as described in the Inquiry may be used in water-wetted service in welded construction complying with the rules of Section I, provided the following additional requirements are met:

(a) The maximum allowable stress values for the material shall be those given in Section II, Part D, Table 1B. The metal temperature shall not exceed 1,250°F (677°C).

(b) Welded fabrication shall conform to the applicable requirement of Section I. When welding is performed with filler metal of the same nominal composition as the base metal, only GMAW and GTAW processes are allowed.

(c) Welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(d) All rules regarding weld strength reduction factors in PG-26 shall apply. Values for weld strength reduction factors shall be as listed in [Table 2](#).

(e) When heat treatment is applied, the temperature, time, and method of heat treatment shall be covered by agreement between the user and manufacturer. When this material is formed, the rules of Section I, PG-19 shall apply for alloy UNS N06230. Other than these requirements, any other heat treatment after forming or fabrication is neither required nor prohibited.

(f) For Section I, which requires a temperature-dependent parameter, y [see PG-27.4, Note (6)], the y values shall be as shown in PG-27.4.

(g) This Case number shall be referenced in the documentation of the material and recorded on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual cold-work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials and can result in severe under-deposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Product Specifications

Seamless pipe and tube	SB-622
Welded tube	SB-626

Table 2
Weld Strength Reduction Factors

Temperature		Weld Strength Reduction Factor
°F	°C	
-20 to 100	-4 to 38	0.85
700	371	0.85
750	399	0.85
800	427	0.85
850	454	0.85
900	482	0.85
950	510	0.85
1,000	538	0.85
1,050	566	0.85
1,100	593	0.85
1,150	621	0.82
1,200	649	0.77
1,250	677	0.73

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Case 2757-2

Alternative Welding Operator Performance Weld Qualification Test

Section I; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX

Approval Date: July 15, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a production mockup weld test be used for welding operator performance qualifications when the welding equipment cannot produce a standard test coupon or a production groove weld capable of volumetric examination or mechanical testing required by QW-300, QW-301, QW-302, or QW-305?

Reply: It is the opinion of the Committee that a production mockup weld test may be used for welding operator performance qualifications when the welding equipment cannot produce a standard test coupon or a production groove weld capable of volumetric examination or mechanical testing required by QW-300, QW-301, QW-302, or QW-305, provided the following requirements are met:

(a) The production mockup test weld shall be sectioned to provide four weld cross-section surfaces equidistant in the length of the test weld.

(b) One face of each cross-section shall be smoothed and etched with a suitable etchant (QW-470) to give clear definition to the weld metal and heat-affected zone.

(c) Visual inspection of the cross-section of the weld metal and heat-affected zone shall be free of cracks and show complete fusion. For partial penetration designs, linear indications at the root not exceeding $\frac{1}{32}$ in. (0.8 mm) shall be acceptable.

(d) In addition to the welding operator performance variables of QW-361, the following essential variables shall apply:

(1) change in the equipment from that used for qualification

(2) change from mechanical weld path control to electronic weld path control

(e) Welding operators qualified under these provisions shall be qualified to weld components of like geometry in sizes larger or smaller than the test coupon.

(f) This Case number shall be shown on the Manufacturer's Data Report and the Welding Operator Performance Qualification Record.

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Case 2758

SA-240/SA-240M, UNS S43035 Plate

Section VIII, Division 1

Approval Date: January 10, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ferritic stainless steel UNS S43035 plate conforming to SA-240/SA-240M Type 439 be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that ferritic stainless steel UNS S43035 plate material conforming to SA-240/SA-240M Type 439 may be used in construction of welded pressure vessels under the rules of Section VIII, Division 1, Part UHA, provided the following additional requirements are met:

(a) The Maximum Allowable Stresses and Notes shall be those shown for 18Cr-Ti, seamless tube, SA-268, UNS S43035 material in Section II, Part D, Table 1A.

(b) The maximum use temperature is 600°F (316°C).

(c) For external pressure design, Figure CS-2 of Section II, Part D shall be used.

(d) This material shall be considered P-No. 7, Group No. 2, as shown in Section IX, Table QW/QB-422 and Non-mandatory Appendix D.

(e) Postweld heat treatment is not required if the following requirements are met:

(1) The plate thickness at welded joint does not exceed $\frac{3}{8}$ in. (10 mm).

(2) For thicknesses over $\frac{3}{8}$ in. (10 mm) to 1.5 in. (38 mm), a preheat of 450°F (230°C) is maintained during welding, and the joints are completely radiographed.

(f) Impact testing requirements for ferritic stainless steels in UHA-51 shall apply.

(g) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2759

Use of SA-705/SA-705M, XM-12, Condition H1025 for Yoke-Supported End Plugs

Section VIII, Division 3

Approval Date: January 10, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SA-705/SA-705M, XM-12, condition H1025 material be used for yoke supported end plugs in Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that SA-705/SA-705M, XM-12, condition H1025 material may be used for yoke-supported end plugs in Section VIII, Division 3

construction, provided the following additional requirements are met:

(a) The material shall be in hydrostatic compression during all loading cycles. Hydrostatic compression is assumed to exist if the sum of the three principal stresses is negative (compressive) at all locations within the component.

(b) The material shall have maximum measured yield strength not in excess of 25 ksi (170 MPa) above the specified minimum value.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2760-1

Attaching Tubes to Tubesheets Using Laser Beam Welding Without Full Penetration

Section IV

Approval Date: December 12, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may tubes exposed to primary furnace gases be attached using laser beam welding (LBW) to a tubesheet that has tube holes that are neither beveled nor recessed and extend through the tubesheet less than the distance required by Table HW-713 and HLW-413?

Reply: It is the opinion of the Committee that tubes exposed to primary furnace gases may be attached using laser beam welding (LBW) to a tubesheet that has tube holes that are neither beveled nor recessed and extend through the tubesheet less than the distance required by Table HW-713 and HLW-413, provided the following requirements are met:

(a) Each tube shall pass through the tubesheet, and its end shall be at least flush with the tubesheet surface to be welded.

(b) Welding procedure and performance qualification shall be conducted in accordance with Section IX, QW-193. Essential procedure qualification variables applicable to the LBW process listed in QW-250 shall be observed in addition to the variables listed in QW-288.

(c) The minimum depth of penetration of tube-to-tubesheet weld shall be at least 1.25 times the thickness of the tube.

(d) The ability of the welding equipment to achieve the correct penetration shall be verified weekly for each LBW unit. This shall be done by macro-examination in accordance with QW-193.1.3 to confirm the required depth of penetration as defined in (c) of one production mockup weld duplicating the tube-to-tubesheet weld design.

(e) In case of failure to meet (d), one immediate retest shall be allowed on two production mockup welds. If not passed for each, the test shall be treated as failed.

(f) In case of failure to meet (e), the LBW unit that failed to pass the verification test shall be excluded from further production process until corrective actions have been implemented to the acceptance of the AI.

(g) In addition to (f), the production units that were produced the week before the weekly test with use of the LBW unit that did not pass the verification test shall be subjected to additional evaluation. If necessary, corrective actions shall be implemented to the acceptance of the AI.

(h) Results from each examination shall be documented and stored by the Manufacturer in form of a test report.

(i) All other requirements of Section IV shall be met.

(j) This Case number shall be shown on the Manufacturer's Data Report.

NOTE: This Case shall become mandatory 6 months after the approval date. Until this date, its use may be optional.

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Case 2761-1

Use of UNS S32205 Ferritic/Austenitic Stainless Steel^{1,2,3} Plate, Pipe, and Tube

Section IV

Approval Date: November 7, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S32205 ferritic/austenitic stainless steel in SA-240 plate, SA-790 pipe, and SA-789 tube specifications be used in the construction of Section IV hot water heating boilers?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the welded construction of Section IV hot water heating boilers, provided the following requirements are met:

(a) The allowable stress for plate, seamless pipe, and seamless tube in accordance with SA-240, SA-789, and SA-790 shall be as listed in [Tables 1](#) and [1M](#).

(b) The allowable stress for welded pipe and tube in accordance with SA-789 and SA-790 shall be as listed in [Tables 2](#) and [2M](#).

(c) Welding procedure and performance qualification shall be conducted in accordance with Section IX.

(d) For external pressure, Section II, Part D, Figure HA-5 shall be used.

(e) The maximum design temperature shall be 500°F (260°C).

(f) All other requirements of Section IV shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

¹This steel may be expected to develop embrittlement after service at moderately elevated temperatures; see Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

²This material may utilize the minimum thickness exceptions of HF-301.1(c) to pressures of 160 psig (1 100 kPa).

³Tubing may utilize the thickness requirements of HF-204.3.

Table 1
Maximum Allowable Stress Values for SA-240 Plate, Seamless SA-789 Tube, and Seamless SA-790 Pipe

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	19.0
200	19.0
300	18.3
400	17.6
500	17.2

Table 1M
Maximum Allowable Stress Values for SA-240 Plate, Seamless SA-789 Tube, and Seamless SA-790 Pipe

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	131
100	131
150	126
200	122
250	119
275	118 [Note (1)]

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C is provided for interpolation purposes.

Table 2
Maximum Allowable Stress Values for Welded SA-789 Tube, and Welded SA-790 Pipe

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
100	16.2
200	16.2
300	15.6
400	15.0
500	14.6

NOTE: (1) For welded pipe and tube, the allowable stress values have been multiplied by a factor of 0.85.

Table 2M
Maximum Allowable Stress Values for Welded SA-789 Tube, and Welded SA-790 Pipe

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
40	111
100	111
150	107
200	104
250	101
275	100 [Note (2)]

NOTES:

- (1) For welded pipe and tube, the allowable stress values have been multiplied by a factor of 0.85.
- (2) The maximum use temperature shall be 260°C. Datum for 275°C is provided for interpolation purposes.

Case 2763-2

Alloy SUS 430J1L/JIS G 4305:2005 Plates for Part HF

Section IV

Approval Date: November 29, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may Alloy SUS 430J1L plate meeting the material requirements of JIS G 4305:2005 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that SUS 430J1L plate meeting the material requirements of JIS G 4305:2005 [see General Note (b) of Table 1] may be used in the construction of heating boilers under Section IV Part HF, provided the following requirements are met:

(a) The allowable stress values for the plates in accordance with Alloy SUS 430J1L shall be as listed in [Tables 1](#) and [1M](#).

(b) The minimum tensile strength shall be 56.5 ksi (390 MPa).

(c) The minimum yield strength shall be 29.5 ksi (205 MPa).

(d) For the purpose of welding and brazing procedures and performance qualifications, this material shall be considered P-No. 7, Group No. 2 for welding, and as P-No. 102 or AWS B2.2/B2.2M, BM 150 for brazing.

(e) For external pressure, Figure CS-2 of Section II, Part D shall be used.

(f) The maximum design temperature shall be 500°F (260°C).

(g) The water temperature shall not exceed 250°F (125°C).

(h) This material with a minimum thickness of 0.0157 in. (0.4 mm) may be used for the construction of Section IV heating boilers, provided the stainless steel plate is not exposed to primary furnace gases.

(i) All other requirements of Section IV shall be met.

(j) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for
JIS G 4305:2005 Gr. SUS 430J1L

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	11.3
150	11.3
200	11.2
250	11.1
300	11.0
400	10.7
500	10.4

GENERAL NOTES:

- (a) This material may utilize the minimum thickness exemption as shown in HF-301.1 (c).
- (b) See Nonmandatory Appendix A in order to obtain an English copy of the specification.

Table 1M
Maximum Allowable Stress Values for
JIS G 4305:2005 Gr. SUS 430J1L

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	78.0
65	77.9
100	77.2
150	75.7
200	73.9
225	73.0
250	72.1
275 [Note (1)]	71.2

GENERAL NOTES:

- (a) This material may utilize the minimum thickness exemption as shown in HF-301.1 (c).
- (b) See Nonmandatory Appendix A in order to obtain an English copy of the specification.

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

Case 2765-2

Alloy SUS 430J1L/JIS G 4305:2005 Plates for Part HLW

Section IV

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may Alloy SUS 430J1L meeting the material requirements of JIS G 4305:2005 be used in the construction of water heaters per Section IV, Part HLW?

Reply: It is the opinion of the Committee that SUS 430J1L meeting the material requirements of JIS G 4305:2005 (see Table 1, General Note) may be used in the construction of water heaters, Section IV, Part HLW provided the following requirements are met:

(a) The allowable stress values for the plates in accordance with Alloy SUS 430J1L shall be as listed in Tables 1 and 1M.

(b) The minimum tensile strength shall be 56.5 ksi (390 MPa).

(c) The minimum yield strength shall be 29.5 ksi (205 MPa).

(d) For the purpose of welding and brazing procedure and performance qualifications, this material shall be considered P-No. 7, Group No. 2 for welding, and as P-No. 102 or AWS B2.2/B2.2M, BM 150 for brazing.

(e) For external pressure, Figure CS-2 of Section II, Part D shall be used.

(f) All other requirements of Section IV shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for
JIS G 4305:2005 Gr. SUS 430J1L

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	14.1
150	14.1
200	14.0
250	13.9
300	13.7
400	13.4
500	13.0

GENERAL NOTE: See Nonmandatory Appendix A in order to obtain an English copy of the specification.

Table 1M
Maximum Allowable Stress Values for
JIS G 4305:2005 Gr. SUS 430J1L

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
40	97.5
65	97.4
100	96.5
150	94.6
200	92.4
225	91.3
250	90.2
275 [Note (1)]	89.1

GENERAL NOTE: See Nonmandatory Appendix A in order to obtain an English copy of the specification

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes

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Case 2767

Use of Welded UNS N02200, N02201, and N04400 Alloy Pipe and Tube

Section VIII, Division 1

Approval Date: June 18, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible in welded construction conforming to the rules of Section VIII, Division 1 to use welded UNS N02200, N02201, or N04400 alloy pipe or tube conforming to the requirements of ASTM B725-05(2009) or ASTM B730-08, as applicable?

Reply: It is the opinion of the Committee that the materials described in the Inquiry may be used in Section VIII, Division 1 construction, provided the following requirements are met:

(a) The maximum allowable design stress for UNS N02200 pipe or tube shall be 85% of the stresses shown in Section II, Part D, Table 1B for annealed SB-162 UNS N02200 plate, sheet, and strip.

(b) The maximum allowable design stress for UNS N02201 pipe or tube shall be 85% of the stresses shown in Section II, Part D, Table 1B for annealed SB-162 UNS N02201 plate, sheet, and strip.

(c) The maximum allowable design stress for UNS N04400 pipe or tube shall be 85% of the stresses shown in Section II, Part D, Table 1B for annealed SB-127 UNS N04400 plate.

(d) For external pressure design, use Figure NFN-2 of Section II, Part D for UNS N02200; use Figure NFN-1 of Section II, Part D for UNS N02201; use Figure NFN-3 of Section II, Part D for UNS N04400.

(e) UNS N02200 and N02201 materials shall be considered P-No. 41.

(f) UNS N04400 material shall be considered P-No. 42.

(g) Heat treatment after welding is neither required nor prohibited.

(h) This Case number shall be included in the Manufacturer's Data Report.

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Case 2770-1

Grade 91 Steel, 9%Cr-1%Mo (UNS K90901)

Section I

Approval Date: November 2, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May austenitized and tempered UNS K90901 material that meets the specification requirements of SA-989/SA-989M for hot isostatically-pressed alloy steel powder metallurgy parts for high temperature service be used for Section I components for welded construction?

Reply: It is the opinion of the Committee that austenitized and tempered UNS K90901 material conforming to SA-989/SA-989M for hot isostatically-pressed alloy steel powder metallurgy parts may be used for Section I welded construction, provided the following additional requirements are met:

(a) For purposes of welding procedure and performance qualification, this material shall be considered P-No. 15E.

(b) The material shall be austenitized within the temperature range of 1,900°F to 1,975°F (1040°C to 1080°C), followed by air or accelerated cooling, and tempered within the range of 1,350°F to 1,470°F (730°C to 800°C).

(c) The maximum allowable stress values for the material shall be those given in [Tables 1](#) and [1M](#).

(d) The maximum use temperature is 1,200°F (649°C).

(e) SA-989/SA-989M Supplementary Requirements S2, S4, S5, and S14 shall apply.

(f) The material shall be examined using either the magnetic particle or liquid penetrant inspection method per SA-989/SA-989M Supplementary Requirements S6 or S7.

(g) Weld repairs to the material shall be made with one of the following welding processes and consumables:

(1) SMAW, SFA-5.5/SFA-5.5M E90XX-B91

(2) SAW, SFA-5.23/SFA-5.23M EB91 + neutral flux

(3) GTAW, SFA-5.28/SFA-5.28M ER90S-B91

(4) FCAW, SFA-5.29/SFA-5.29M E91T1-B9

In addition, the Ni + Mn content of all welding consumables shall not exceed 1.2%.

(h) Weld repairs to the material as a part of manufacture shall be made with welding procedures and welders qualified in accordance with Section IX.

(i) Repair by welding shall not exceed 10% of the part surface area and $3\frac{1}{3}\%$ of wall thickness of the finished part or $\frac{3}{4}$ in. (19 mm), whichever is less, without prior approval of the purchaser.

(j) If during the manufacturing any portion of the component is heated to a temperature greater than 1,470°F (800°C), then the component shall be reaustenitized and retempered in its entirety in accordance with [\(b\)](#).

(k) Yield strength, tensile strength, external pressure, and physical properties used shall be the same as found in SA-335 for Grade 91, Type 1.

(l) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
-20 to 100	24.3
200	24.3
300	24.3
400	24.2
500	24.1
600	23.7
650	23.4
700	22.9
750	22.2
800	21.3
850	20.3
900	19.1
950	17.8
1,000	16.1 [Note (1)]
1,050	12.2 [Note (1)]
1,100	8.7 [Note (1)]
1,150	5.7 [Note (1)]
1,200	3.5 [Note (1)]

NOTE: (1) These stress values are obtained from time dependent properties.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
-30 to 40	168
65	168
100	168
125	168
150	168
200	167
250	166
300	164
325	163
350	161
375	157
400	153
425	147
450	141
475	134
500	126
525	117
550	98.5 [Note (1)]
575	75.5 [Note (1)]
600	54.3 [Note (1)]
625	36.8 [Note (1)]
650	24.0 [Note (1)][Note (2)]

NOTES:

- (1) These stress values are obtained from time dependent properties.
- (2) The maximum use temperature shall be 649°C. Datum for 650°C temperature is provided for interpolation purposes.

Case 2771

SA-738/SA-738M, Grade E Steel Plates

Section VIII, Division 3

Approval Date: June 18, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use quenched and tempered SA-738/SA-738M Grade E steel plate in construction of welded pressure vessels conforming to the rules of Section VIII, Division 3?

Reply: It is the opinion of the Committee that quenched and tempered steel plate conforming to SA-738/SA-738M, Grade E may be used in the construction of welded pressure vessels conforming to the rules of Section VIII, Division 3, provided the following additional requirements are met:

(a) The maximum thickness of the plate shall be 2 in. (50 mm).

(b) The maximum thickness at welded joints shall not exceed 1¼ in. (32 mm).

(c) The vessel components shall not be used for pressure parts subject to direct firing.

(d) The yield and tensile strength values shall be those shown in Tables 1 and 2, respectively, of this Case.

(e) The reduction of area for the base plate in tensile tests shall be at least 45%.

(f) The physical properties are the same as those for SA-738/SA-738M Grade B.

(g) Except for cutting and welding, heating of the material above 1,100°F (593°C) during fabrication is not permitted. Postweld heat treatment of the material is not required.

(h) Welding procedures and performance qualifications shall be conducted in accordance with Section IX. Separate welding procedure qualifications are required for this material. For performance qualifications this material shall be considered as P-No. 1.

(i) Welding by electroslag or electrogas processes is not permitted.

(j) Materials certification shall be in accordance with KM-101.

(k) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Values of Yield Strength

Specification, Grade	Yield Strength, ksi (MPa), for Metal Temperature of 100°F (40°C)	Yield Strength, ksi (MPa), for Metal Temperature of 150°F (65°C)
SA-738, Grade E	75 (515)	75 (515)

Table 2
Values of Tensile Strength

Specification, Grade	Tensile Strength, ksi (MPa), for Metal Temperature of 100°F (40°C)	Tensile Strength, ksi (MPa), for Metal Temperature of 150°F (65°C)
SA-738, Grade E	90 (620)	90 (620)

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Case 2772

Exceptions to Requirements of Figure UW-13.2, Sketches (m) and (n)

Section VIII, Division 1

Approval Date: June 18, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the a , b , and c dimensions in Figure UW-13.2, sketches (m) and (n) for flanges calculated as integral type in accordance with Mandatory Appendix 2 be based on the required nozzle thickness rather than the nominal nozzle thickness?

Reply: It is the opinion of the Committee that the a , b , and c dimensions in Figure UW-13.2, sketches (m) and (n) for flanges calculated as integral type in accordance with Mandatory Appendix 2 may be based on the required nozzle thickness rather than the nominal nozzle thickness, provided the following additional requirements are met:

(a) The a dimension in Figure UW-13.2, sketches (m) and (n) shall not be less than the nominal nozzle thickness, t_n , plus $\frac{1}{4}$ in.

(b) The required nozzle thickness, $t_{r\ n2}$, shall be used in the calculations in Mandatory Appendix 2 in place of the nominal nozzle thickness, t_n . The required nozzle thickness, $t_{r\ n2}$, shall be equal to or greater than the minimum neck thickness required for internal and external pressure using UG-27 and UG-28 (plus corrosion allowance), as applicable. The effects of external forces and moments from supplemental loads (UG-22) shall be considered (see Figure 1).

(c) The g_1 dimension used in the calculations in Mandatory Appendix 2 shall be equal to 3 times the required thickness, $3t_{r\ n2}$.

(d) The g_0 dimension used in the calculations in Mandatory Appendix 2 shall be equal to the required thickness, $t_{r\ n2}$.

(e) The h dimension used in the calculations in Mandatory Appendix 2 shall be equal to g_1 from (c) minus g_0 from (d).

(f) The results of the calculations using the dimensions described in (b), (c), (d), and (e) shall meet all requirements of Section VIII, Division 1, including those in Mandatory Appendix 2, considering all applicable loads.

(g) Additional calculations shall be performed using the nominal nozzle thickness, t_n but with the g_1 dimension set to the same value as in (c).

(h) The g_0 dimension used in the additional calculations described in (g) shall be equal to the nominal nozzle thickness, t_n .

(i) The h dimension used in the additional calculations described in (g) shall be equal to g_1 from (g) minus g_0 from (h).

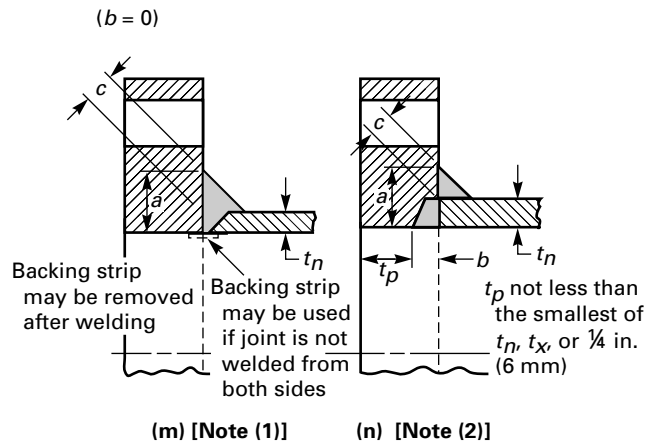
(j) The results of the calculations using the dimensions described in (g), (h), and (i) shall meet all requirements of Section VIII, Division 1, including those in Mandatory Appendix 2, considering all applicable loads.

(k) The longitudinal hub stress, S_H , calculated in accordance with (g) through (i) using the nominal nozzle thickness shall be less than the longitudinal hub stress, S_H , calculated using the required nozzle thickness in accordance with (b) through (e).

(l) The nominal nozzle thickness, t_n , shall not be less than the required nozzle thickness, $t_{r\ n2}$.

(m) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Typical Bolted Flange Connections



GENERAL NOTES:

- (a) c , t_n , and t_x are as defined in 2-3 of Section VIII, Division 1.
- (b) $t_{r\ n2}$ is as defined in (b) of this Case.

NOTES:

- (1) $a \geq 3t_{r\ n2}$ and $\geq t_n + \frac{1}{4}$ in. (6 mm); $c \geq$ lesser of $t_{r\ n2}$ or t_x
- (2) $a + b \geq 3t_{r\ n2}$ and $\geq t_n + \frac{1}{4}$ in. (6 mm); $c \geq$ lesser of $t_{r\ n2}$ or t_x

Case 2773

Use of Sand Cast Aluminum Alloy EN AC-43000, AlSi10Mg(a), F Temper

Section IV

Approval Date: August 27, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may aluminum alloy EN AC-43000, AlSi10Mg(a), F temper, sand castings meeting the requirements of Part HA, used in the construction of heating boilers be exempt from the radii requirements of HA-303?

Reply: It is the opinion of the Committee that aluminum alloy EN AC-43000, AlSi10Mg(a), F temper, sand castings used in the construction of heating boilers may be exempt from the radii requirements of HA-303 under the following conditions:

(a) The material is limited to EN AC-43000, AlSi10Mg(a).

(b) All other applicable parts of Section IV shall apply.

(c) This Case number shall be shown on the H-5A Data Report.

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Case 2774

Waiver of Weld Joint Examination for Pneumatically Tested Brazed Plate-Type Heat Exchangers That Have Been Previously Hydrostatically Tested

Section VIII, Division 1

Approval Date: September 18, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: When an aluminum-brazed plate-type heat exchanger has been hydrostatically tested at a test pressure in accordance with UG-99, and it will be subsequently pneumatically tested in accordance with UG-100, under what circumstances may the weld joint examination requirements of UW-50 be waived?

Reply: It is the opinion of the Committee that when an aluminum-brazed plate-type heat exchanger has been hydrostatically tested at a test pressure in accordance

with UG-99, the weld joint examination requirements of UW-50 prior to pneumatic testing in accordance with UG-100 may be waived, provided all welds that were made after the hydrostatic test have been examined in accordance with UW-50 prior to applying the pneumatic test.

A record of the hydrostatic test shall be documented in the Manufacturer's assembly process control records in such a manner that any welds made after testing can be readily identified; witnessing of the hydrostatic test by the Authorized Inspector is not required.

This Case number shall be shown on the Manufacturer's Data Report.

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Case 2775

Use of 57Ni-22Cr-14W-2Mo-La (UNS N06230), Solution-Annealed Bolting Materials for Pressure Vessels

Section VIII, Division 1

Approval Date: September 18, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may 57Ni-22Cr-14W-2Mo-La (UNS N06230), solution-annealed rod, and forging material, conforming to the requirements of SB-564 and SB-572 be used as bolting material in the manufacture of Section VIII, Division 1 pressure vessels?

Reply: It is the opinion of the Committee that 57Ni-22Cr-14W-2Mo-La (UNS N06230), solution-annealed rod, and forging material, conforming to the requirements of

SB-564 and SB-572 may be used as bolting material in the manufacture of Section VIII, Division 1 pressure vessels, provided the following requirements are met:

(a) The design temperature shall not exceed 1,650°F (899°C).

(b) The maximum allowable stress values shall be those listed in [Tables 1](#) and [1M](#).

(c) The applicable rules of Section VIII, Division 1, Part UNF for nickel alloys shall be met.

(d) Welding is not permitted.

(e) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	27.5
200	27.5
300	26.4
400	24.7
500	23.1
600	22.0
650	21.5
700	21.2
750	21.0
800	20.9
850	20.9
900	20.9
950	20.9
1,000	20.9
1,050	20.9
1,100	20.9
1,150	19.0 [Note (1)]
1,200	15.6 [Note (1)]
1,250	12.9 [Note (1)]
1,300	10.6 [Note (1)]
1,350	8.5 [Note (1)]
1,400	6.7 [Note (1)]
1,450	5.3 [Note (1)]
1,500	4.1 [Note (1)]
1,550	2.9 [Note (1)]
1,600	2.1 [Note (1)]
1,650	1.5 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

Table 1M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	190
65	190
100	190
125	188
150	182
175	176
200	171
225	166
250	161
275	157
300	153
325	150
350	148
375	146
400	145
425	144
450	144
475	144
500	144
525	144
550	144
575	144
600	144
625	128 [Note (1)]
650	107 [Note (1)]
675	89.7 [Note (1)]
700	74.7 [Note (1)]
725	61.9 [Note (1)]
750	50.8 [Note (1)]
775	41.1 [Note (1)]
800	32.8 [Note (1)]
825	25.2 [Note (1)]
850	18.9 [Note (1)]
875	13.8 [Note (1)]
900 [Note (2)]	10.2 [Note (1)]

NOTES:

- (1) These values are obtained from time-dependent properties.
- (2) The maximum use temperature is 899°C, and the value at 900°C shall be used for interpolation purposes only

Case 2776

Use of 52Ni-22Cr-13Co-9Mo (UNS N06617), Annealed Bolting Materials for Pressure Vessels

Section VIII, Division 1

Approval Date: September 18, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may 52Ni-22Cr-13Co-9Mo (UNS N06617), annealed rod, bar, and forging material, conforming to the requirements of SB-166 and SB-564 be used as bolting material in the manufacture of Section VIII, Division 1 pressure vessels?

Reply: It is the opinion of the Committee that 52Ni-22Cr-13Co-9Mo (UNS N06617), annealed rod, bar, and forging material, conforming to the requirements of SB-166 and

SB-564 may be used as bolting material in the manufacture of Section VIII, Division 1 pressure vessels, provided the following requirements are met:

(a) The design temperature shall not exceed 1,650°F (899°C).

(b) The maximum allowable stress values shall be those listed in [Tables 1](#) and [1M](#).

(c) The applicable rules of Section VIII, Division 1, Part UNF for nickel alloys shall be met.

(d) Welding is not permitted.

(e) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	23.3
200	20.8
300	19.2
400	18.1
500	17.2
600	16.6
650	16.4
700	16.2
750	16.0
800	15.9
850	15.8
900	15.7
950	15.6
1,000	15.5
1,050	15.4
1,100	15.4
1,150	15.3
1,200	15.3
1,250	14.5 [Note (1)]
1,300	11.2 [Note (1)]
1,350	8.7 [Note (1)]
1,400	6.6 [Note (1)]
1,450	5.1 [Note (1)]
1,500	3.9 [Note (1)]
1,550	3.0 [Note (1)]
1,600	2.3 [Note (1)]
1,650	1.8 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

Table 1M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	161
65	152
100	142
125	136
150	132
175	129
200	125
225	122
250	120
275	117
300	115
325	114
350	113
375	111
400	110
425	110
450	109
475	108
500	108
525	107
550	106
575	106
600	106
625	105
650	105
675	101 [Note (1)]
700	81.0 [Note (1)]
725	64.1 [Note (1)]
750	50.4 [Note (1)]
775	39.5 [Note (1)]
800	31.3 [Note (1)]
825	24.6 [Note (1)]
850	19.4 [Note (1)]
875	15.3 [Note (1)]
900 [Note (2)]	12.3 [Note (1)]

NOTES:

- (1) These values are obtained from time-dependent properties.
- (2) The maximum use temperature is 899°C, and the value at 900°C shall be used for interpolation purposes only.

Case 2777-1

Use of Resistance Longitudinal Butt Welds for Cylinders

Section VIII, Division 1; Section VIII, Division 2; Section IX

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may resistance longitudinal butt welds for cylinders be qualified in accordance with Section IX?

Reply: It is the opinion of the Committee that resistance longitudinal butt welds for cylinders may be qualified in accordance with Section IX, provided the following conditions are met:

(a) *Welding Procedure Specification (WPS) Qualification*

(1) The base material shall be P-No. 1 with a thickness of 0.054 in. (1.4 mm) minimum to 0.075 in. (1.9 mm) maximum.

(2) The welding procedure shall be qualified by preparing a longitudinal butt weld test coupon, observing and recording the values for the essential and nonessential variables from [Table 1](#).

(3) The completed test coupon shall be subjected to the mechanical tests required by QW-451.1.

(4) The welded test coupon may be flattened prior to testing.

(5) As an alternative to QW-196, resistance welding shall be tested as butt joint weld.

(6) As an alternative to QW-196.2, resistance butt welds shall be tested in accordance with QW-150 and QW-160.

(7) As an alternative to QW-286, resistance butt welds shall be tested in accordance with QW-150 and QW-160.

(8) In addition to QW-402.1, a change from a butt weld joint to any other weld joint is not permitted.

(9) As an alternative to QW-409.15(a)(6), strip feed rate shall be used.

(10) When used for the construction of pressure vessel shells under the rules of Section VIII, Division 1 or 2, the longitudinal ERW weld shall be considered a Type 1 joint whose joint efficiency shall only be improved by a ultrasonic examination performed in accordance with Section VIII, Division 2, para. 7.5.5.

(b) As an alternative to QW-384, welder operator qualification for resistance butt welds shall be in accordance with QW-305 and QW-361.

(c) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Resistance Welding Variables for Longitudinal Butt Joints for Cylinders

Paragraph	Subparagraph	Brief of Variables	Essential	Non-Essential
QW-402	.1	∅ Butt joint	X	...
QW-403	.21	± Coating, plating	X	...
	.22	± <i>T</i>	X	...
QW-407	.1	∅ PWHT	X	...
QW-409	.15(a)(4)	∅ Pressure	X	...
	.15(a)(5)	∅ Current	X	...
	.15(a)(6)	∅ Current time	X	...
	.15(b)	∅ AC to DC	X	...
	.17	∅ Power supply	X	...
	.18	Tip cleaning	...	X
QW-410	.31	∅ Cleaning method	X	...
	.33	∅ Equipment	X	...
	.34	∅ Cooling medium	...	X

Case 2778

Use of UNS S32205 Ferritic/Austenitic Stainless Steel Plate, Sheet, Strip, Pipe, and Tube in the Manufacture of Part HLW Water Heaters and Storage Tanks

Section IV

Approval Date: September 18, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S32205 ferritic/austenitic stainless steel in SA-240 plate, sheet, strip, SA-790 pipe, and SA-789 tube specifications be used in the construction of unlined Section IV, Part HLW water heaters and storage tanks?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the welded construction of Section IV, Part HLW water heaters and storage tanks, provided the following requirements are met:

(a) The allowable stress for plate, seamless pipe, and seamless tube in accordance with SA-240, SA-789, and SA-790 shall be as listed in [Table 1](#) and [Table 1M](#).

(b) The allowable stress for welded pipe and tube in accordance with SA-789 and SA-790 shall be as listed in [Table 2](#) and [Table 2M](#).

(c) Welding procedure and performance qualification shall be conducted in accordance with Section IX.

(d) As an alternative to calculation using the listed stress values, the allowable working pressure of the water or storage tank may be established in accordance with the proof test provision of HLW-500.

(e) For external pressure, Figure HA-5 of Section II, Part D shall be used.

(f) The maximum design temperature shall be 500°F (260°C).

(g) All other requirements of Section IV shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for SA-240 Plate, Sheet, Strip, Seamless SA-790 Pipe, and Seamless SA-789 Tube

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	23.8
200	23.8
300	22.9
400	22.1
500	21.5

Table 1M
Maximum Allowable Stress Values for SA-240 Plate, Sheet, Strip, Seamless SA-790 Pipe, and Seamless SA-789 Tube

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	164
100	164
150	158
200	152
250	149
275	148 [Note (1)]

NOTE: (1) The maximum use temperature shall be 260°C. The value at 275°C temperature is provided for interpolation purposes.

Table 2
Maximum Allowable Stress Values for Welded SA-790 Pipe, and Welded SA-789 Tube

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	20.2
200	20.2
300	19.5
400	18.7
500	18.3

GENERAL NOTE: For welded pipe tube, the allowable stress values have been multiplied by a factor of 0.85.

Table 2M
Maximum Allowable Stress Values for Welded SA-790 Pipe, and Welded SA-789 Tube

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	139
100	139
150	134
200	130
250	127
275	126 [Note (1)]

GENERAL NOTE: For welded pipe tube, the allowable stress values have been multiplied by a factor of 0.85.

NOTE: (1) The maximum use temperature shall be 260°C. The value at 275°C temperature is provided for interpolation purposes.

Case 2779

SA/EN10028-2 Grades P235GH, P265GH, P295GH, and P355GH

Section IV

Approval Date: September 18, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may Grades P235GH, P265GH, P295GH and P355GH meeting the material requirements of SA/EN10028-2 be used in the construction of heating boilers?

Reply: It is the opinion of the Committee that Grades P235GH, P265GH, P295GH and P355GH meeting the material requirements of SA/EN10028-2 may be used in the construction of heating boilers, Part HF, provided the following requirements are met:

(a) The allowable stress values for Grades P235GH, P265GH, P295GH, and P355GH shall be as listed in [Table 1](#) and [1M](#).

(b) For the purpose of welding procedure and performance qualifications, Grades P235GH, P265GH, P295GH shall be considered P-No. 1, Group 1, and Grade P355GH shall be considered P-No. 1, Group 2.

(c) For external pressure, Section II, Part D, Figure CS-2 shall be used.

(d) The maximum design temperature shall be 500°F (260°C).

(e) The water temperature shall not exceed 250°F (125°C).

(f) All other requirements of Section IV shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding °F	Allowable Stress Values, ksi			
	Grade P235GH	Grade P265GH	Grade P295GH	Grade P355GH
-20 to 100	9.9	11.3	12.5	13.6
150	9.9	11.3	12.5	13.6
200	9.9	11.3	12.5	13.6
250	9.9	11.3	12.5	13.6
300	9.9	11.3	12.5	13.6
350	9.9	11.3	12.5	13.6
400	9.9	11.3	12.5	13.6
450	9.9	11.3	12.5	13.6
500	9.9	11.3	12.5	13.6

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding °C	Allowable Stress Values, MPa			
	Grade P235GH	Grade P265GH	Grade P295GH	Grade P355GH
-30 to 40	68.0	78.0	86.0	94.0
65	68.0	78.0	86.0	94.0
100	68.0	78.0	86.0	94.0
125	68.0	78.0	86.0	94.0
150	68.0	78.0	86.0	94.0
175	68.0	78.0	86.0	94.0
200	68.0	78.0	86.0	94.0
225	68.0	78.0	86.0	94.0
250	68.0	78.0	86.0	94.0
275 [Note (1)]	68.0	78.0	86.0	94.0

NOTE: (1) The maximum allowable temperature is 260°C. The values 275°C may only be used for interpolation.

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Case 2780-1

24Cr-4Ni-3Mn-1.6Mo-0.27N, UNS S82441 Ferritic/Austenitic Steel, Alloy Plate, Sheet, and Strip; Bar; Seamless and Welded Tube; Seamless and Welded Pipe

Section VIII, Division 1

Approval Date: June 1, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S82441 ferritic/austenitic stainless steel in accordance with A240/A240M-15, ASTM A479/A479M-14, ASTM A789/A789M-14, and ASTM A790/A790M-14a be used in Section VIII, Division 1 welded construction?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section VIII, Division 1 welded construction, provided the following requirements are met:

(a) The physical properties for UNS S82441 are as follows:

(1) mean linear thermal expansion coefficients, as given in [Tables 1](#) and [1M](#)

(2) thermal conductivity, as given in [Tables 2](#) and [2M](#)

(3) density: 0.277 lb/in.³ (7700 kg/m³)

(4) modulus of elasticity at 68°F (20°C): 29.7 × 10⁶ psi (205 × 10³ MPa)

(5) Poisson's ratio: 0.3

(b) The yield strength and tensile strength values for use in design shall be as shown in [Tables 3](#) and [3M](#) and [Tables 4](#) and [4M](#), respectively.

(c) The maximum allowable stress values for the material shall be those given in [Tables 5](#) and [5M](#) and [Tables 6](#) and [6M](#). The maximum design temperature shall be 600°F (316°C).

(d) The allowable stress values in [Tables 5](#), [5M](#), [6](#), and [6M](#) shall be multiplied by 0.85 to determine the allowable stress values for welded tube and welded pipe.

(e) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. This material shall be considered P-No. 10H, Group 1.

(f) Heat treatment after welding is neither required nor prohibited, but if it is performed it shall be an annealing heat treatment as required by the material specifications.

(g) For external pressure design, Figure HA-5 shall be used.

(h) The rules for austenitic/ferritic duplex stainless steels in Section VIII, Division 1, Subsection C, Part UHA shall apply.

(i) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Mean Linear Thermal Expansion Coefficients

Temperature Range, °F	Coefficient
RT – 212	7.2 × 10 ⁻⁶
RT – 392	7.5 × 10 ⁻⁶
RT – 572	7.8 × 10 ⁻⁶

Table 1M
Mean Linear Thermal Expansion Coefficients

Temperature Range, °C	Coefficient
RT – 100	13.0 × 10 ⁻⁶
RT – 200	13.5 × 10 ⁻⁶
RT – 300	14.0 × 10 ⁻⁶

Table 2
Thermal Conductivity

Temperature, °F	Btu/hr-ft-°F
RT (68)	8.4
212	9.2
392	10.4
572	12.1

Table 2M
Thermal Conductivity

Temperature, °C	W/m °C
RT (20)	14.5
100	16
200	18
300	21

Table 3
Yield and Tensile Strength Values, ≥ 0.4 in. for ASTM A240/A240M, ASTM A789/A789M, and ASTM A790/A790M;
 $\geq 7/16$ in. for A479/A479M

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
75	69.5	98.6
100	63.3	98.6
200	53.0	92.9
300	48.6	89.6
400	45.3	87.9
500	44.1	87.9
600	44.1	87.9
650	44.0	87.9
700	39.7	85.4

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 3M
Yield and Tensile Strength Values, ≥ 10 mm for ASTM A240/A240M, ASTM A789/A789M, and ASTM A790/A790M;
 ≥ 11 mm for A479/A479M

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
21	480	680
40	432	680
65	392	665
100	361	637
125	347	626
150	335	617
175	323	611
200	314	607
225	307	606
250	304	606
275	304	606
300	304	606
325	304	606
350	300	606
375	267	582

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 4
Yield and Tensile Strength Values, < 0.4 in. for ASTM A240/A240M, ASTM A789/A789M, and ASTM A790/A790M;
< 7/16 in. for A479/A479M

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
75	78.3	107
100	71.2	107
200	69.7	101
300	54.7	97.5
400	51.0	95.7
500	49.6	95.7
600	49.6	95.7
650	49.6	95.7
700	44.7	93.0
750	32.2	80.9

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 4M
Yield and Tensile Strength Values, < 10 mm for ASTM A240/A240M, ASTM A789/A789M, and ASTM A790/A790M;
< 11 mm for A479/A479M

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
21	540	740
40	486	740
65	441	723
100	406	693
125	390	681
150	376	672
175	364	665
200	353	660
225	345	659
250	342	659
275	342	659
300	342	659
325	342	659
350	337	659
375	300	633
400	217	523

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 5
Maximum Allowable Stress Values, for 70 ksi Y.S/99 ksi T.S.; ≥ 0.4 in. for ASTM A240/A240M, ASTM A789/A789M, and ASTM A790/A790M; ≥ 7/16 in. for ASTM A479/A479M

For Metal Temperature Not Exceeding, °F	Stress, ksi
75	28.2
100	28.2
200	26.5
300	25.6
400	25.1
500	25.1
550	25.1
600	25.1

PRECAUTIONARY NOTE: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

Table 5M
Maximum Allowable Stress Values, for 480 MPa Y.S/680 MPa T.S.; ≥ 10 mm for ASTM A240/A240M, ASTM A789/A789M, and ASTM A790/A790M; ≥ 11 mm for ASTM A479/A479M

For Metal Temperature Not Exceeding, °C	Stress, MPa
21	194
40	184
65	184
100	182
125	179
150	176
175	175
200	173
225	173
250	173
275	173
300	173
325 [Note (1)]	173

PRECAUTIONARY NOTE: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

NOTE: (1) The value at 325°C is for interpolation only. The maximum use temperature is 316°C.

Table 6
Maximum Allowable Stress Values, for 78 ksi Y.S/107 ksi T.S.; < 0.4 in. for ASTM A240/A240M, ASTM A789/A789M, and ASTM A790/A790M; < 7/16 in. for ASTM A479/A479M

For Metal Temperature Not Exceeding, °F	Stress, ksi
75	30.7
100	30.7
200	28.9
300	27.8
400	27.3
500	27.3
600	27.3

PRECAUTIONARY NOTE: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

Table 6M
Maximum Allowable Stress Values, for 540 MPa Y.S/740 MPa T.S.; < 10 mm for ASTM A240/A240M, ASTM A789/A789M, and ASTM A790/A790M; < 11 mm for ASTM A479/A479M

For Metal Temperature Not Exceeding, °C	Stress, MPa
21	211
40	211
65	207
100	198
125	194
150	192
175	190
200	189
225	188
250	188
275	188
300	188
325 [Note (1)]	188

PRECAUTIONARY NOTE: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

NOTE: (1) The value at 325°C is for interpolation only. The maximum use temperature is 316°C.

Case 2781-3

12Cr-1.5W-1.6Co-B Material

Section I

Approval Date: May 12, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 12Cr-1.5W-1.6Co-B seamless tubes and pipes conforming to the chemical analysis shown in [Table 1](#), the mechanical properties listed in [Table 2](#), and otherwise conforming to the applicable requirements of SA-213/SA-213M and SA-335/SA-335M be used for Section I construction?

Reply: It is the opinion of the Committee that normalized and tempered seamless 12Cr-1.5W-1.6Co-B tubes and pipes as described in the Inquiry may be used for Section I construction, provided the following requirements are met:

(a) The material shall be austenitized within the temperature range 1,900°F to 1,975°F (1 040°C to 1 080°C) followed by air cooling and tempered within the range 1,400°F to 1,470°F (760°C to 800°C).

(b) The material in the final tempered condition shall not exceed a Brinell Hardness Number of 250 HBW (HRC 25).

(c) The maximum design temperature shall be 1,200°F (649°C).

(d) The maximum allowable stress values for the material shall be those given in [Table 3](#) or [Table 3M](#).

(e) Welding shall be limited to GTAW, GMAW, or SMAW. Separate weld procedure qualification shall apply for this material. For the purpose of performance qualification, the material shall be considered P-No 15F. The performance qualification shall be conducted as prescribed in Section IX.

(f) Exemptions to postweld heat treatment for this material shall be in accordance with the rules for P-No 15E materials in Table PW-39-5. When applicable, the postweld heat treatment shall be performed at 1,365°F to 1,435°F (740°C to 780°C) for a minimum of ½ hr.

(g) All cold formed material that is designed for service at a nominal temperature of 1,000°F (540°C) or higher shall be heat treated in accordance with the following rules. Cold bending or forming is defined as any method that produces strain in the material and is performed at a temperature below 1,200°F (650°C).

The calculations of cold strains shall be made as described in PG-19.

(1) Heat treatments required by the following subparagraphs shall not be performed locally. The material shall be either heat treated in its entirety, or the cold-strained area (including the transition) shall be cut away from the balance of the tube or component and heat treated separately or replaced.

(2) For all cold swages, flares, and upsets regardless of the dimension and the amount of cold reduction, the material shall be re-austenitized and tempered in accordance with (a).

(3) For design temperatures exceeding 1,000°F (540°C) but less than or equal to 1,115°F (600°C), and cold-forming strains greater than 25%, the material shall be normalized and tempered in accordance with (a).

(4) For design temperatures exceeding 1,115°F (600°C), and cold-forming strains greater than 20%, the material shall be normalized and tempered in accordance with (a).

(5) For design temperatures exceeding 1,000°F (540°C) but less than or equal to 1,115°F (600°C), and cold-forming strains greater than 5% but less than or equal to 25%, the material shall be stress relieved at a temperature between 1,365°F and 1,435°F (740°C and 780°C), with a soaking time of minimum 1 hr, followed by cooling in air or normalized and tempered in accordance with (a).

(6) For design temperatures exceeding 1,115°F (600°C), and cold-forming strains greater than 5% but less than or equal to 20%, the material shall be stress relieved at a temperature between 1,365°F and 1,435°F (740°C and 780°C), with a soaking time of minimum 1 hr, followed by cooling in air or normalized and tempered in accordance with (a).

(h) All material formed at or above 1,200°F (650°C) shall be re-austenitized and tempered in accordance with (a). This heat treatment shall not be performed locally. The material shall be either heat treated in its entirety, or the hot-formed area (including the transition) shall be cut away from the balance of the tube or component and heat treated separately or replaced.

(i) Except as provided in (j), if during manufacturing any portion of the component is heated to a temperature greater than 1,470°F (800°C), then the component shall be re-austenitized and retempered in its entirety in

accordance with (a), or the portion of the component heated above 1,470°F (800°C), including the heat-affected zone created by the local heating, shall be replaced or shall be removed, renormalized, and tempered and then replaced in the component.

(j) If the allowable stresses to be used are less than or equal to those provided in Section II, Part D, Table 1A for Grade 9 (SA-213 T9 and SA-335/SA-335M P9) at the design temperature, the requirements of (i) may be waived, provided that the portion of the component heated to a temperature greater than 1,470°F (800°C) is reheat treated within the temperature range 1,400°F to 1,470°F (760°C to 800°C).

(k) S_u and S_y values are listed in Table 4 or Table 4M and Table 5 or Table 5M, respectively.

(l) Physical properties are as follows: density: 0.282 lb/in.³ (7810kg/m³). See Table 6 or Table 6M, Physical Properties.

(m) External pressure design is prohibited.

(n) This material is a creep strength-enhanced ferritic (CSEF) steel whose creep temperature strength is enhanced by the creation of a precise condition of microstructure, specifically martensite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbonitrides, or other stable and/or metastable phases. Refer to Section I, PW-10 for additional cautionary information.

CSEF alloys may demonstrate a susceptibility to creep-intolerant behavior, which manifests as limited amount of plastic deformation at the time of creep-rupture.

(o) This Case number shall be referenced in the documentation and marking of the material and shall be shown on the Manufacturer’s Data Report.

**Table 1
Chemical Requirements**

Element	Composition Limits, %
Carbon	0.10–0.14
Manganese	0.15–0.45
Phosphorus, max.	0.020
Sulphur, max.	0.010
Silicon	0.40–0.60
Chromium	11.00–12.00
Molybdenum	0.20–0.40
Vanadium	0.20–0.30
Nickel	0.10–0.40
Boron	0.003–0.006
Nitrogen	0.030–0.070
Cobalt	1.40–1.80
Aluminum, max.	0.02
Copper, max.	0.25
Tungsten	1.30–1.70
Niobium	0.03–0.08

**Table 2
Mechanical Properties Requirements**

Minimum Tensile Strength, ksi (MPa)	Minimum Yield Strength, ksi (MPa)	Minimum Elongation in 2 in. (50.8 mm), %
89.9 (620)	65.3 (450)	19

GENERAL NOTES:

(a) For longitudinal strip tests, a deduction from the basic values of 1.00% for each 1/32 in. (0.8 mm) decrease in wall thickness below 5/16 in. (7.8 mm) shall be made. The following table gives the computed values:

Wall Thickness	Minimum Elongation in 2 in. (50.8 mm), %
5/16 (0.312) in. [7.8 mm]	19.0
9/32 (0.281) in. [7.1 mm]	18.0
1/4 (0.250) in. [6.4 mm]	17.0
7/32 (0.219) in. [5.3 mm]	16.0
3/16 (0.188) in. [4.8 mm]	15.0
5/32 (0.156) in. [4.0 mm]	14.0
1/8 (0.125) in. [3.2 mm]	13.0
3/32 (0.094) in. [2.4 mm]	12.0
1/16 (0.062) in. [1.5 mm]	11.6
0.062 in. to 0.035 in. [0.9 mm to 1.5 mm], excl.	10.9
0.035 in. to 0.022 in. [0.6 mm to 0.9 mm], excl.	10.6
0.022 in. to 0.015 in. [0.4 mm to 0.6 mm], incl.	10.3

(b) Where the wall thickness lies between two values shown in the in-text table above, the minimum elongation value shall be determined by the following equation:

(U.S. Customary Units)

$$E = 32t + 10.00$$

(SI Units)

$$E = 1.25t + 10.00$$

E = elongation in 2 in. (50.8 mm), %

t = actual thickness of specimen, in. (mm)

Table 3
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
-20 to 100	25.7
200	25.7
300	25.4
400	24.5
500	23.9
600	23.5
650	23.2
700	22.9
750	22.6
800	22.0
850	21.4
900	20.5
950	19.5
1,000	18.2
1,050	15.0 [Note (1)]
1,100	10.7 [Note (1)]
1,150	7.0 [Note (1)]
1,200	4.5 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

Table 3M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
-30 to 40	177
100	177
200	169
300	163
400	155
425	152
450	148
475	143
500	137
525	130
550	121 [Note (1)]
575	93.3 [Note (1)]
600	67.2 [Note (1)]
625	45.0 [Note (1)]
650	30.2 [Note (1)], [Note (2)]

NOTES:

- (1) These values are obtained from time-dependent properties.
(2) The maximum use temperature shall be 649°C. Datum for 650°C temperature is provided for interpolation purposes.

**Table 4
Tensile Strength Values, S_u**

For Metal Temperature Not Exceeding, °F	S_u Values, ksi [Note (1)]
-20 to 100	89.9
200	89.9
300	88.8
400	85.7
500	83.7
600	82.2
650	81.4
700	80.3
750	78.9
800	77.1
850	74.7
900	71.7
950	68.1
1,000	63.8
1,050	58.8
1,100	53.2
1,150	47.2
1,200	40.9

NOTE: (1) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

**Table 4M
Tensile Strength Values, S_u**

For Metal Temperature Not Exceeding, °C	S_u Values, MPa [Note (1)]
-30 to 40	620
65	620
100	620
150	612
200	592
250	579
300	570
325	565
350	559
375	553
400	544
425	532
450	518
475	501
500	479
525	454
550	425
575	393
600	357
625	319
650	280 [Note (2)]

NOTES:

- (1) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The maximum use temperature shall be 649°C. Datum for 650°C temperature is provided for interpolation purposes.

Table 5
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °F	S_y Values, ksi [Note (1)]
-20 to 100	65.3
200	63.8
300	61.4
400	59.2
500	57.6
600	56.5
650	56.0
700	55.5
750	54.8
800	53.9
850	52.7
900	51.1
950	49.0
1,000	46.4
1,050	43.2
1,100	39.4
1,150	35.0
1,200	30.0

NOTE: (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 5M
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °C	S_y Values, MPa [Note (1)]
-30 to 40	450
65	446
100	438
150	423
200	409
250	399
300	391
325	388
350	385
375	382
400	378
425	372
450	365
475	356
500	344
525	329
550	311
575	289
600	265
625	237
650	205 [Note (2)]

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The maximum use temperature shall be 649°C. Datum for 650°C temperature is provided for interpolation purposes.

Table 6
Physical Properties

Temperature, °F	Modulus of Elasticity, Tension, 10 ³ ksi	Thermal Conductivity, Btu/ft-hr-°F	Mean CTE, 10 ⁻⁶ in./in./°F [Note (1)]
68	31.91	13.0	...
200	31.25	14.3	5.84
400	30.12	15.0	6.06
600	28.78	15.8	6.25
800	27.13	16.2	6.44
1,000	25.25	16.6	6.67
1,150	23.59	16.8	6.79

NOTE: (1) Mean CTE values are those from 68°F to indicated temperature.

Table 6M
Physical Properties

Temperature, °C	Modulus of Elasticity, Tension, 10 ³ MPa	Thermal Conductivity, W/(m-°C)	Mean CTE, 10 ⁻⁶ mm/mm/°C [Note (1)]
20	220	24.2	...
100	215	25.2	10.5
200	208	26.2	10.9
300	200	27.1	11.2
400	190	27.9	11.5
500	179	28.5	11.8
600	166	29.1	12.1
650	158	29.3	12.2

NOTE: (1) Mean CTE values are those from 20°C to indicated temperature.

Case 2782

Cu-13Zn-1.1Ni-Si-Al Alloy Seamless Pipe and Tubing

Section I

Approval Date: October 23, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May precipitation-hardened Cu-13Zn-1.1Ni-Si-Al alloy (UNS C69100), seamless pipe and tubing conforming to the requirements of ASTM B706-00 (reapproved 2011) be used for nonwelded construction under the rules of Section I?

Reply: It is the opinion of the Committee that precipitation-hardened Cu-13Zn-1.1Ni-Si-Al alloy (UNS C69100), seamless pipe and tubing conforming to the requirements of ASTM B706-00 (reapproved 2011) may be used for nonwelded construction under the rules of Section I, provided the following additional requirements are met:

(a) The pipe and tubing shall be in the precipitation-hardened condition, temper TF00 in ASTM B706.

(b) The maximum allowable stress values for the material shall be those given in [Table 1](#) or [Table 1M](#). The maximum design temperature shall be 400°F (204°C).

(c) External pressure design is not permitted.

(d) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi
100	17.1
150	17.1
200	17.1
250	17.1
300	17.1
350	17.1
400	17.1

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress, MPa
40	118
65	118
100	118
125	118
150	118
175	118
200	118
225 [Note (1)]	117

NOTE: (1) The maximum use temperature for this alloy is 400°F (204°C). The value listed at 225°C is provided for interpolation purposes only.

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Case 2783

Cu-13Zn-1.1Ni-Si-Al Alloy Seamless Tubing

Section VIII, Division 1

Approval Date: September 28, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May precipitation-hardened Cu-13Zn-1.1Ni-Si-Al alloy (UNS C69100), seamless pipe and tubing conforming to the requirements of ASTM B706-00 (reapproved 2011) be used for nonwelded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that precipitation-hardened Cu-13Zn-1.1Ni-Si-Al alloy (UNS C69100), seamless pipe and tubing conforming to the requirements of ASTM B706-00 may be used for nonwelded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The pipe and tubing shall be in the precipitation-hardened condition, temper TF00 in ASTM B706.

(b) Heat treatment shall be age-hardening at $1,110^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($600^{\circ}\text{C} \pm 15^{\circ}\text{C}$) for 3 hr to 4 hr followed by air cooling.

(c) The physical properties for Cu-13Zn-1.1Ni-Si-Al alloy (UNS C69100) are as follows:

(1) density, 68°F (20°C): 0.307 lb/in.^3 (8520 kg/m^3)

(2) thermal conductivity

(-a) 212°F (100°C): $44 \text{ Btu/(h}\cdot\text{ft}\cdot^{\circ}\text{F)}$ ($77 \text{ W/m}\cdot\text{K}$)

(-b) 572°F (300°C): $59.5 \text{ Btu/(h}\cdot\text{ft}\cdot^{\circ}\text{F)}$ ($103 \text{ W/m}\cdot\text{K}$)

(3) Coefficient of thermal expansion, $10^{-6}/^{\circ}\text{F}$: 11 ($10^{-6}/\text{K}$: 19)

(d) The yield strength and tensile strength values for use in design shall be as shown in [Tables 1](#) and [1M](#).

(e) The maximum allowable stress values for the material shall be those given in [Tables 2](#) and [2M](#). The maximum design temperature shall be 400°F (204°C).

(f) External pressure design is prohibited.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
100	31.0	60.0
150	30.8	60.0
200	30.8	60.0
250	30.8	60.0
300	30.4	60.0
350	29.8	60.0
400	29.2	60.0

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 1M
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
40	212	414
65	212	414
100	212	414
125	212	414
150	210	414
175	206	414
200	202	414
225	199	409

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 requires elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	17.1
150	17.1
200	17.1
250	17.1
300	17.1
350	17.1
400	17.1

Table 2M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	118
65	118
100	118
125	118
150	118
175	118
200	118
225 [Note (1)]	117

NOTE: (1) The maximum use temperature for this alloy is 400°F (204°C). The value listed at 225°C is provided for interpolation purposes only.

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Case 2784

Use of 17Cr-4Ni-4Cu (UNS S17400) Condition H1150D or H1150M

Section VIII, Division 1

Approval Date: November 1, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May martensitic precipitation hardened stainless steel 17Cr-4Ni-4Cu (UNS S17400) complying with SA-564 Type 630 condition H1150D or H1150M be used for bodies, bonnets, and yokes of pressure-relief devices constructed under Section VIII, Division 1?

Reply: It is the opinion of the Committee that martensitic precipitation hardened stainless steel 17Cr-4Ni-4Cu (UNS S17400) complying with SA-564 Type 630 condition H1150D or H1150M may be used for bodies, bonnets, and yokes of pressure-relief devices constructed under Section VIII, Division 1, provided the following additional requirements are met:

(a) The material shall be in the H1150D or H1150M condition.

(b) The yield strength and tensile strength values for use in design shall be as shown in Table 1 and Table 1M, and Table 2 and Table 2M.¹

(c) The maximum allowable stress values for the material shall be as those given in Table 3 and Table 3M, and Table 4 and Table 4M. The maximum design shall be 700°F (371°C).

(d) For welding, the rules in Article KF-11 on additional fabrication requirements for welding age-hardening stainless steels in Section VIII, Division 3 (2011a addenda) shall apply.

(e) Minimum design metal temperature (MDMT) shall be -50°F (-46°C).

(f) Impact testing is required for UNS S17400 materials in tempers H1150D or H1150M. Impact testing is not required when the maximum obtainable Charpy specimen has a width along the notch less than 0.099 in. (2.5 mm). The minimum lateral expansion opposite the notch shall be no less than 0.015 in. (0.38 mm).

(g) All other requirements of Section VIII, Division 1 shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

¹ The allowable stress values in this Case are based on consensus that using trend curves on 900°F (482°C) (H900 temper) aged material data is conservative for the grades covered by this Case.

Table 1
Yield and Tensile Strength Values for Condition H1150M

For Metal Temperatures Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
100	75	115
150	71.3	...
200	69.4	109
250	67.8	...
300	66.5	105
350	65.2	...
400	64.1	102
450	63.1	...
500	62.1	99.6
550	61.3	...
600	60.6	98.1
650	59.7	97.2
700	58.9	95.9

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 1M
Yield and Tensile Strength Values for Condition H1150M

For Metal Temperatures Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
40	515	795
65	489	795
100	473	795
150	456	795
200	441	774
250	429	760
300	418	749
325	414	744
350	409	737
375	404	728

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 2
Yield and Tensile Strength Values for Condition H1150D

For Metal Temperatures Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
100	105	125
150	99.8	...
200	97.1	119
250	94.9	...
300	93.0	114
350	91.2	...
400	89.7	111
450	88.3	...
500	86.9	108
550	85.8	...
600	84.8	107
650	83.6	106
700	82.4	104

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 2M
Yield and Tensile Strength Values for Condition H1150D

For Metal Temperatures Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
40	725	860
65	689	860
100	666	860
150	642	860
200	621	837
250	604	822
300	589	811
325	582	805
350	576	797
375	568	787

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the tensile strength values tend toward an average or expected value, which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section VIII, Division 1 require elevated temperature testing for tensile strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 3
Maximum Allowable Stress Values for Condition H1150M

For Metal Temperatures Not Exceeding, °F	Stress, ksi
100	32.9
200	32.9
300	32.9
400	31.9
500	31.3
600	30.8
650	30.5
700	30.1

CAUTION: This material has reduced toughness at room temperature after exposure for about 5,000 hr at or above 600°F.

Table 3M
Maximum Allowable Stress Values for Condition H1150M

For Metal Temperatures Not Exceeding, °C	Stress, MPa
40	227
65	227
100	227
150	227
200	221
250	217
300	214
325	213
350	211
375 [Note (1)]	208

CAUTION: This material has reduced toughness at room temperature after exposure for about 5,000 hr at or above 600°F.

NOTE: (1) The value at 375°C is for interpolation only. The maximum use temperature is 371°C.

Table 4
Maximum Allowable Stress Values for Condition H1150D

For Metal Temperatures Not Exceeding, °F	Stress, ksi
100	35.7
200	35.7
300	35.7
400	34.7
500	34.0
600	33.5
650	33.2
700	32.8

CAUTION: This material has reduced toughness at room temperature after exposure for about 5,000 hr at or above 600°F.

Table 4M
Maximum Allowable Stress Values for Condition H1150D

For Metal Temperatures Not Exceeding, °C	Stress, MPa
40	246
65	246
100	246
150	246
200	239
250	235
300	232
325	230
350	228
375 [Note (1)]	225

CAUTION: This material has reduced toughness at room temperature after exposure for about 5,000 hr at or above 600°F.

NOTE: (1) The value at 375°C is for interpolation only. The maximum use temperature is 371°C.

Case 2786

Alloy UNS S30815 Up to 1,700°F (927°C)

Section I; Section VIII, Division 1

Approval Date: November 1, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed 21Cr-11Ni-N alloy (UNS S30815) seamless and welded pipe and tube, plate, forgings and bar be used in Section I and Section VIII, Division 1 welded construction at temperatures above 1,650°F (900°C) up to and including 1,700°F (927°C)?

Reply: It is the opinion of the Committee that solution annealed 21Cr-11Ni-N alloy (UNS S30815) in the product forms described in the Inquiry may be used for Section I and Section VIII, Division 1 welded construction at temperatures above 1,650°F (900°C) up to and including 1,700°F (927°C), provided the following additional requirements are met:

(a) A list of approved SA specifications is shown in Table 1.

(b) The maximum allowable stress values shall be those given in Table 2 and Table 2M.

(c) Allowable stress values in this Case are values obtained from time-dependent properties.

(d) For welding, the material has been assigned P-No. 8, Group 2.

(e) This Case number shall be referenced in documentation and marking of the material and shown on the Manufacturer's Data Report.

Table 1
Specifications

Specification	Item	Identification Symbol or UNS Number
SA-182	Forgings	F 45
SA-213	Seamless tube	UNS S30815
SA-240	Plate, sheet, and strip	UNS S30815
SA-249	Welded tube	UNS S30815
SA-312	Seamless pipe, welded pipe	UNS S30815
SA-479	Bar	UNS S30815

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi	Maximum Allowable Stress (Welded), ksi
1,700	0.58	0.49

GENERAL NOTES:

- (a) Creep fatigue, thermal ratcheting, and environmental effects are increasingly significant failure modes at these temperatures.
 (b) Values for 1,650°F and lower can be found in Section II, Part D (Customary), Table 1A.

Table 2M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa	Maximum Allowable Stress (Welded), MPa
925	4.08	3.47
950 [Note (1)]	3.47	2.95

GENERAL NOTES:

- (a) Creep fatigue, thermal ratcheting, and environmental effects are increasingly significant failure modes at these temperatures.
 (b) Values for 900°C and lower can be found in Section II, Part D (Metric), Table 1A.

NOTE: (1) The maximum use temperature is 927°C; the value given at 950°C is given for interpolation only.

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Case 2787-2

Multiple Marking of Certified Capacities for Pressure-Relief Valves

Section VIII, Division 1; Section XIII

Approval Date: September 19, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a Manufacturer or Assembler of a pressure-relief valve with a UV Designator place more than one certified capacity on the pressure-relief valve or the nameplate and comply with Section XIII, 3.9?

Reply: It is the opinion of the Committee that a Manufacturer or Assembler of a pressure-relief valve with a UV Designator may place more than one certified capacity on the valve or nameplate provided the following requirements are met:

(a) The pressure-relief valve has been capacity certified by the Manufacturer per the requirements of Section XIII, Part 9 for each of the medias with the following additional requirements:

(1) During the certification of capacity testing required per Section XIII, Part 9, the pressure-relief valve shall be tested first on one of the certified media

(steam, air, gas, or water) and then tested on all other media requested by the Manufacturer.

(2) There shall be no adjustments to any of the pressure-relief valves after completion of the testing on the first media.

(3) The measured set pressure for the valve tested on the additional medias shall meet the tolerance requirements of Section XIII, Table 3.6.3.1-2, based on the pressure at which the valve was set to operate in (1), or marked set pressure for sample production valves.

(b) The pressure-relief valve shall meet all requirements of Section XIII, Part 3 for all certified capacities marked on the valve or nameplate except as follows:

(1) For sample production pressure-relief valves selected for capacity certification or recertification per Section XIII, 3.4.2.1, the same requirements per (a) shall apply.

(2) Production testing per Section XIII, 3.6.3 shall be performed using any one of the certified medias to be marked on the valve except steam shall be used when one of the capacities marked on the pressure-relief valve or nameplate is steam.

(c) This Case number shall be on a plate permanently attached to the pressure-relief valve.

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Case 2789-1

Laser Measurement for Out-of-Roundness

Section VIII, Division 1; Section VIII, Division 2

Approval Date: September 19, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For pressure vessels under external pressure, may a laser measurement system be used in lieu of the segmental circular template as specified in Section VIII, Division 1, UG-80(b)(2) and Section VIII, Division 2, 4.4.4 and 4.4.4.1(b)?

Reply: It is the opinion of the Committee that a laser measurement system may be used in lieu of the segmental circular template as specified in Section VIII, Division 1, UG-80(b)(2) and Section VIII, Division 2, 4.4.4 and 4.4.4.1(b) for pressure vessels under external pressure under the following conditions:

(a) Circularity (roundness) is a condition of a surface where all points of the surface intersected by any plane perpendicular to the axis are equidistant from that axis or spine.

(b) The laser measurement system shall be capable of obtaining a measurement that varies from the nominal diameter by no more than $D/20,000$.

(c) The laser measurement system shall be performance tested and used within the rated conditions as specified in Form 1 of ASME B89.4.19-2006.

(d) The laser measurements shall be taken a minimum of two times for each area under consideration, and the measurements shall be compared. If the two data sets differ by more than 20% of the tolerance for the item being measured, the item shall be remeasured until two subsequent data sets are within 20% of the tolerance from each other.

(e) The vessel section under consideration shall use either of the following two methods for determining compliance to the out-of-roundness tolerance of Section VIII, Division 1, UG-80(b)(2) and Section VIII, Division 2, 4.4.4 and 4.4.4.1(b):

(1) evaluation of measurements over the same arc lengths as defined in Section VIII, Division 1, UG-80(b)(2) and Section VIII, Division 2, 4.4.4 and 4.4.4.1(b) for a segmental circular template

(2) evaluation of measurements for circularity as defined in (a) using the average diameter of the section and the tolerance provided from Section VIII, Division 1, Figure UG-80.1 and Section VIII, Division 2, 4.4.4 and 4.4.4.1(b)

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2790

Use of Type XM-12, Condition H900 Material With a Reduced Tensile Strength

Section VIII, Division 3

Approval Date: November 1, 2013

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May Type XM-12, Condition H900 Material with a reduced tensile strength but otherwise meeting all of the requirements of SA-705 Type XM-12, Condition H900 material be used in Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that Type XM-12, Condition H900 Material with a reduced tensile strength but otherwise meeting all of the requirements of SA-705 Type XM-12, Condition H900 material may be used in Section VIII, Division 3 construction provided the following additional requirements are met:

(a) The design temperature shall not exceed 100°F (40°C).

(b) The minimum specified tensile strength shall be 187 ksi (1 290 MPa).

(c) The minimum specified yield strength shall be 170 ksi (1 170 MPa).

(d) All other mechanical properties shall meet the requirements for SA-705, Type XM-12, condition H900 material.

(e) The tensile strength values used in design S_u shall be obtained from [Table 1](#).

(f) The yield strength values for use in design shall be obtained from Section II, Part D, Table Y-1. The values for SA-705, Type XM-12, condition H900 shall be used.

(g) Mechanical property tests shall be in accordance with Article KM-2 for SA-705, Type XM-12, condition H900 material.

(h) Charpy V-notch testing is required. The results shall be reported to the Manufacturer of the pressure vessel.

(i) This material is permitted only when used as an inner layer in a vessel whose design meets the leak-before-burst criteria of KD-141.

(j) Caution is advised when using this material as it is more susceptible than lower strength materials to environmental stress corrosion cracking and/or embrittlement due to hydrogen exposure. This susceptibility increases as yield strength increases. The designer shall consider these effects and their influences on the vessel. See Section II, Part D, Nonmandatory Appendix A, A-701.

(k) No welding is permitted on this material.

(l) The materials manufacturer shall certify that the material meets all requirements in SA-705 for Type XM-12, Condition H900 material with the exception that the tensile strength meets the requirements of this Case.

(m) This Case number shall be shown on the marking and certification of the material and shown on the Manufacturer's Data Report.

Table 1
Tensile Strength Values

Temperature, °F (°C)	Tensile Strength, ksi (MPa)
-20 to 100 (-30 to 40)	187 (1290)

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Case 2791

Joining of SB-283, UNS C37700 Fittings to SB-75 Tubing

Section IV

Approval Date: January 6, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SB-283, UNS C37700 fittings be joined to SB-75 tubing by brazing in Section IV construction?

Reply: It is the opinion of the Committee that SB-283, UNS C37700 fittings may be joined to SB-75 tubing by brazing in Section IV construction, provided the following requirements are met:

(a) Brazing procedure and performance qualifications shall be conducted in accordance with Section IX.

(b) All other applicable Code requirements shall be met.

(c) This Case number shall be shown on the Data Report.

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Case 2792

57Ni-22Cr-14W-2Mo-La Alloy (UNS N06230) Wrought and Welded Tubing

Section I; Section II, Part B; Section VIII, Division 1

Approval Date: January 23, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-annealed alloy UNS N06230 wrought and welded tubing tested with a flare test in lieu of a flange test and otherwise conforming to Section II, Part B, SB-626 be used in welded construction under the rules of Section I and Section VIII, Division 1?

Reply: It is the opinion of the Committee that solution-annealed alloy UNS N06230 wrought and welded tubing tested with a flare test in lieu of a flange test and otherwise

conforming to Section II, Part B, SB-626 may be used in welded construction under the rules of Section I and Section VIII, Division 1, provided the following additional requirements are met:

(a) The flare test shall be as described in para. 6.3 of SB-751 or para. A2.5.1.5 of SA-370.

(b) Use of welded tubes with a flare angle greater than 30 deg is prohibited.

(c) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

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Case 2793

Use of SA-705/SA-705M, Type XM-12, Condition H1025 for Primary Pressure Boundary Components in Contact With Water or Aqueous Solution

Section VIII, Division 3

Approval Date: March 18, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SA-705/SA-705M, Type XM-12, Condition H1025 material be used for external yoke supported plugs and wedges for wire wound pressure vessels in contact with water or an aqueous solution for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that SA-705/SA-705M, Type XM-12, Condition H1025 material may be used for external yoke supported plugs and wedges for wire wound pressure vessels in contact with water or an aqueous solution in Section VIII, Division 3 construction, provided the following requirements are met:

(a) The plugs shall consist of cylindrical components that provide end closures on cylindrical vessels and that are supported by an external yoke such that the plug is in axial compression.

(b) The wedges shall consist of components that fit between the plugs and the yoke and that transmit the loads from the plug to the yoke in axial compression.

(c) It shall be demonstrated using fracture mechanics analysis that cracks that may initiate at any location within the component where one or more of the principal stresses is tensile, and/or where the sum of the three principal stresses is positive will propagate into a zone where the range of stress intensity is below the threshold for crack growth due to either environmental cracking or fatigue before reaching the critical value for fast fracture.

(d) As an alternative to (c), it may be demonstrated that the component will fail in a leak-before-burst manner considering all credible crack configurations and if personnel can be protected from any harmful effects of the leaking fluid.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2794

Solution Annealed Ni-24Fe-23Cr-6Mo-3Cu, UNS N06845, Seamless Pipe and Tube, Plate, Sheet, Strip, Rod, and Bar

Section VIII, Division 1

Approval Date: March 18, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution-annealed Ni-24Fe-23Cr-6Mo-3Cu, UNS N06845, seamless pipe and tube, plate, sheet, strip, rod, and bar conforming to the requirements of the specifications listed in [Table 1](#) be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that solution annealed Ni-24Fe-23Cr-6Mo-3Cu, UNS N06845, seamless pipe and tube, plate, sheet, strip, rod, and bar as described in the Inquiry may be used for welded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The rules of Section VIII, Division 1, Part UNF for nickel alloys shall apply.

(b) The maximum design temperature shall be 842°F (450°C).

(c) The maximum allowable stress values shall be as shown in [Table 2](#) and [2M](#).

(d) The yield and tensile strength values for use in design shall be as shown in [Table 3](#) and [Table 3M](#).

(e) For external pressure, [Figure 1](#) and [1M](#) and the tabular values in [Table 4](#) shall apply. For values of A falling to the left of the applicable material/temperature curve, determine factor B from the tabular values in [Table 4](#) or use the elastic modulus values from [Tables 5](#) and [5M](#) in the expression for external pressure in Section VIII, Division 1 that uses E.

(f) Separate weld procedure and performance qualifications conducted in accordance with Section IX shall be required for this material.

(g) Welding of this material to itself is restricted to GTAW with welding consumable ER NiCrCoMo-1.

(h) Heat treatment after welding or fabrication is neither required nor prohibited.

(i) This Case number shall be shown on the Manufacturer's Data Report.

(j) When required, the following physical properties shall apply:

(1) Modulus of elasticity values are as shown in [Tables 5](#) and [5M](#).

(2) Mean linear thermal expansion coefficients values are as shown in [Tables 6](#) and [6M](#).

(3) Thermal conductivity and thermal diffusivity values are as shown in [Tables 7](#) and [7M](#).

(4) The density for the material at room temperature is 0.304 lb/in.³ (8410 kg/m³).

(5) Poisson's ratio is 0.31.

Table 1
Material Specifications and Grades

Material	Specification and UNS Number
Condenser and Heat-Exchanger Tubes	ASTM B163-11 N06845
Seamless Pipe and Tubes	ASTM B423-11 N06845
Plate, Sheet, and Strip	SB-424 N06845
Rod and Bar	ASTM B425-11 N06845

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi	Stress, ksi [Note (1)]
100	26.7	26.7
150	23.2	26.7
200	21.8	26.7
250	20.7	26.7
300	19.8	26.7
350	19.2	25.9
400	18.6	25.2
450	18.2	24.5
500	17.8	24.0
550	17.4	23.5
600	17.1	23.1
650	16.9	22.8
700	16.7	22.5
750	16.5	22.3
800	16.4	22.2
850	16.3 [Note (2)]	22.0 [Note (2)]

NOTES:

- (1) Section II, Part D, Subpart 1, Table 1B, Note G5 applies to these values.
- (2) The maximum design temperature is 842°F. This value is provided for interpolation purposes only.

Table 3
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
100	40.0	100
150	34.8	100
200	32.6	100
250	31.0	99.4
300	29.8	97.0
350	28.8	94.9
400	28.0	93.1
450	27.3	91.5
500	26.7	90.2
550	26.1	89.2
600	25.7	88.3
650	25.3	87.7
700	25.0	87.1
750	24.8	86.6
800	24.6	85.9
850	24.4	85.0
900	24.1	83.6

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, Note (b) applies to these values.
- (2) Section II, Part D, Subpart 1, Table U, Note (b) applies to these values.

Table 2M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress, MPa	Stress, MPa [Note (1)]
40	184	184
65	160	184
100	148	184
125	142	184
150	137	184
175	133	179
200	129	174
225	126	170
250	124	167
275	121	164
300	119	161
325	117	159
350	116	157
375	115	155
400	114	154
425	113	153
450	112	152

NOTE: (1) Section II, Part D, Subpart 1, Table 1B, Note G5 applies to these values.

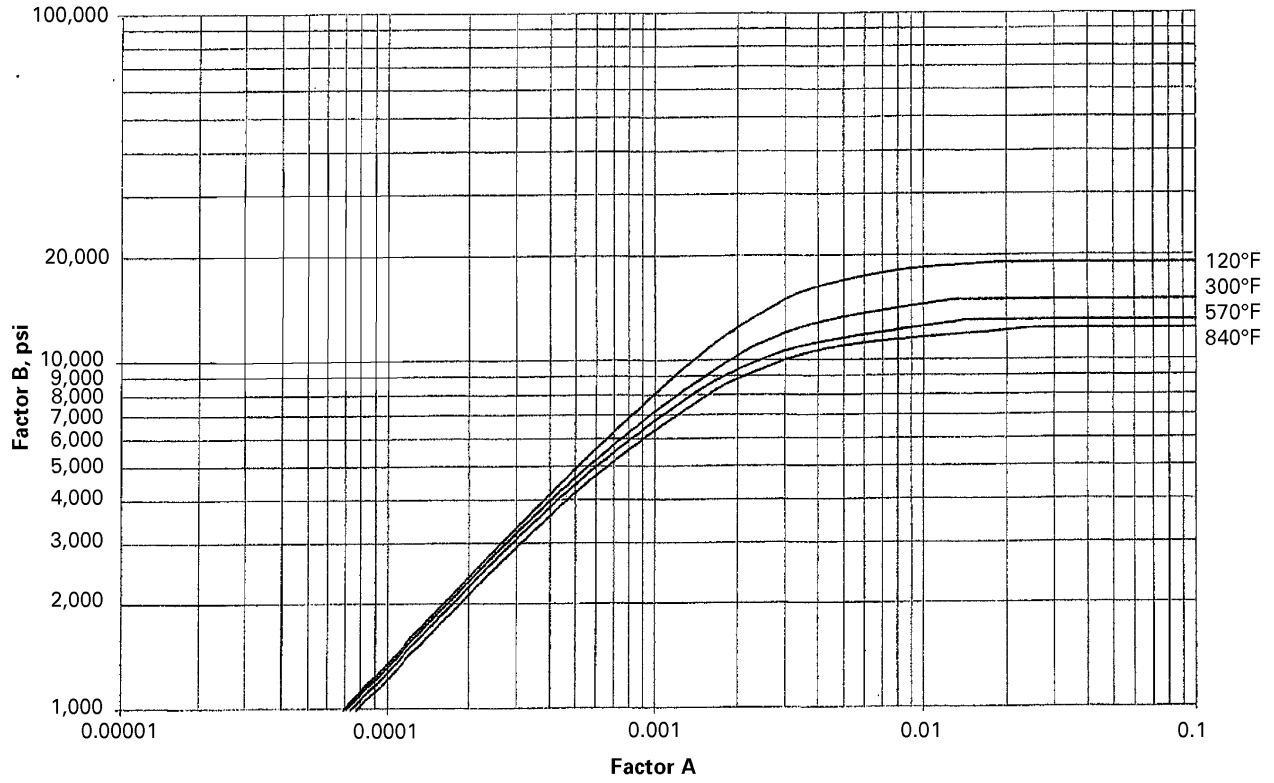
Table 3M
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
40	276	690
65	240	690
100	222	690
125	212	683
150	205	668
175	199	655
200	194	644
225	189	634
250	185	625
275	182	618
300	179	612
325	176	607
350	174	603
375	172	600
400	171	597
425	170	593
450	169	587

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, Note (b) applies to these values.
- (2) Section II, Part D, Subpart 1, Table U, Note (b) applies to these values.

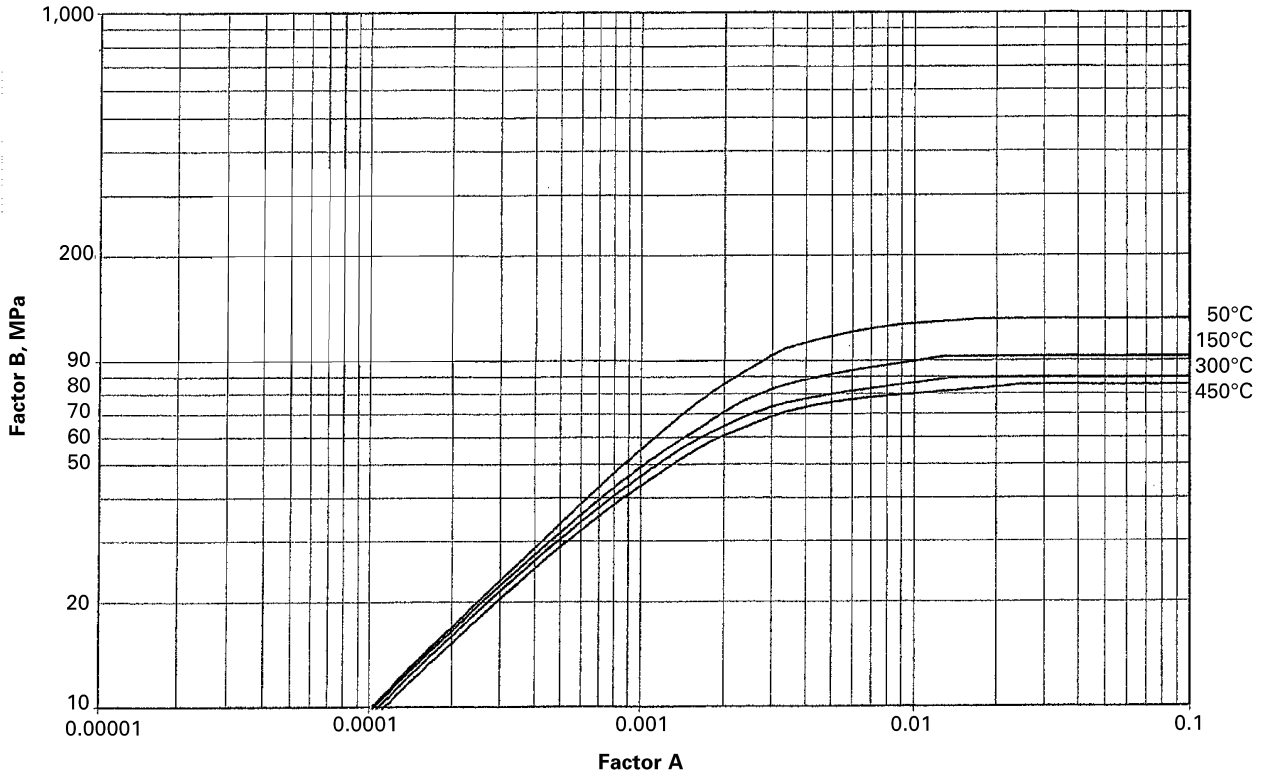
Figure 1
External Pressure Chart for UNS N06845



GENERAL NOTE: For Factor A to the left of chart line

Temperature, °F	E, psi × 10 ⁶
120	28.6
300	27.9
570	26.7
840	25.4

Figure 1M
External Pressure Chart for UNS N06845



GENERAL NOTE: For Factor A to the left of chart line

Temperature, °C	E, MPa × 10 ³
50	197
150	192
300	185
450	176

Table 4
Tabular Values for Figures 1 and 1M

Temperature, °F	A	B, psi	Temperature, °C	A	B, psi
120	1.00 E-05	142	50	1.00 E-05	0.98
	6.99 E-05	1,000		1.02 E-04	10.0
	3.33 E-04	3,600		3.33 E-04	25.0
	8.70 E-04	7,300		8.70 E-04	50.0
	1.58 E-03	10,900		1.58 E-03	75.0
	2.78 E-03	14,500		2.78 E-03	100.0
	4.05 E-03	16,300		4.05 E-03	112.5
	8.06 E-03	18,100		8.06 E-03	125.0
	1.75 E-02	19,000		1.75 E-02	131.0
	1.00 E-01	19,000		1.00 E-01	131.0
300	1.00 E-05	139	150	1.00 E-05	0.96
	7.17 E-05	1,000		1.04 E-04	10.0
	3.50 E-04	3,600		3.50 E-04	25.0
	1.03 E-03	7,300		1.03 E-03	50.0
	1.56 E-03	9,100		1.56 E-03	62.5
	2.50 E-03	11,300		2.50 E-03	78.0
	4.50 E-03	13,100		4.50 E-03	90.0
	1.28 E-02	14,900		1.28 E-02	102.5
	1.00 E-01	14,900		1.00 E-01	102.5
	570	1.00 E-05		133	300	1.00 E-05	0.92
7.46 E-05		1,000	1.08 E-04	10.0	
3.70 E-04		3,600	3.70 E-04	25.0	
1.15 E-03		7,300	1.15 E-03	50.0	
1.80 E-03		9,000	1.80 E-03	62.0	
3.57 E-03		11,000	3.57 E-03	76.0	
1.43 E-02		13,000	1.43 E-02	89.5	
1.00 E-01		13,000	1.00 E-01	89.5	
840		1.00 E-05	128	450		1.00 E-05	0.88
	7.84 E-05	1,000	1.14 E-04		10.0
	4.00 E-04	3,600	4.00 E-04		25.0
	1.30 E-03	7,300	1.30 E-03		50.0
	2.20 E-03	9,100	2.20 E-03		62.5
	4.70 E-03	10,900	4.70 E-03		75.0
	2.45 E-02	12,300	2.45 E-02		85.0
	1.00 E-01	12,300	1.00 E-01		85.0

**Table 5
Modulus of Elasticity**

Temperature, °F	psi × 10 ⁶
RT	28.9
200	28.3
300	27.9
400	27.5
500	27.1
600	26.7
700	26.2
800	25.7
900	25.4
1,000	25.0
1,100	24.6
1,200	24.0
1,300	23.3
1,400	22.7
1,500	22.0

**Table 5M
Modulus of Elasticity**

Temperature, °C	MPa × 10 ³
25	199
100	195
150	192
200	190
250	188
300	185
350	182
400	179
450	176
500	174
550	172
600	169
650	165
700	161
750	157
800	153
850	148

Table 6
Mean Linear Thermal Expansion Coefficients

Temperature Range, °F	Coefficient, in./in./°F
RT-100	7.7×10^{-6}
RT-150	7.7×10^{-6}
RT-200	7.7×10^{-6}
RT-250	7.7×10^{-6}
RT-300	7.8×10^{-6}
RT-350	7.8×10^{-6}
RT-400	7.8×10^{-6}
RT-450	7.9×10^{-6}
RT-500	7.9×10^{-6}
RT-550	8.0×10^{-6}
RT-600	8.0×10^{-6}
RT-650	8.0×10^{-6}
RT-700	8.1×10^{-6}
RT-750	8.1×10^{-6}
RT-800	8.2×10^{-6}
RT-850	8.2×10^{-6}
RT-900	8.2×10^{-6}
RT-950	8.2×10^{-6}
RT-1,000	8.2×10^{-6}
RT-1,050	8.2×10^{-6}
RT-1,100	8.2×10^{-6}
RT-1,150	8.2×10^{-6}
RT-1,200	8.3×10^{-6}
RT-1,250	8.4×10^{-6}
RT-1,300	8.5×10^{-6}
RT-1,350	8.6×10^{-6}
RT-1,400	8.7×10^{-6}
RT-1,450	8.8×10^{-6}
RT-1,500	8.8×10^{-6}

Table 6M
Mean Linear Thermal Expansion Coefficients

Temperature Range, °C	Coefficient, mm/mm/°C
RT-100	13.9×10^{-6}
RT-125	13.9×10^{-6}
RT-150	14.0×10^{-6}
RT-175	14.0×10^{-6}
RT-200	14.1×10^{-6}
RT-225	14.2×10^{-6}
RT-250	14.3×10^{-6}
RT-275	14.3×10^{-6}
RT-300	14.4×10^{-6}
RT-325	14.5×10^{-6}
RT-350	14.5×10^{-6}
RT-375	14.6×10^{-6}
RT-400	14.6×10^{-6}
RT-425	14.7×10^{-6}
RT-450	14.7×10^{-6}
RT-475	14.8×10^{-6}
RT-500	14.8×10^{-6}
RT-525	14.8×10^{-6}
RT-550	14.8×10^{-6}
RT-575	14.7×10^{-6}
RT-600	14.7×10^{-6}
RT-625	14.8×10^{-6}
RT-650	14.9×10^{-6}
RT-675	15.1×10^{-6}
RT-700	15.3×10^{-6}
RT-725	15.5×10^{-6}
RT-750	15.6×10^{-6}
RT-775	15.7×10^{-6}
RT-800	15.8×10^{-6}

**Table 7
Nominal Coefficients of Thermal Conductivity and Thermal Diffusivity**

Temperature, °F	Thermal Conductivity, Btu/hr-ft × °F	Thermal Diffusivity, ft ² /hr
70	5.4	0.105
100	5.6	0.108
150	6.0	0.113
200	6.4	0.118
250	6.8	0.124
300	7.0	0.127
350	7.3	0.130
400	7.6	0.134
450	8.1	0.138
500	8.3	0.140
550	8.7	0.144
600	9.0	0.146
650	9.5	0.152
700	9.7	0.154
750	10.0	0.157
800	10.3	0.161
850	10.6	0.165
900	11.0	0.169
950	11.4	0.172
1,000	11.8	0.174
1,050	12.1	0.176
1,100	12.9	0.181
1,150	14.0	0.190
1,200	14.1	0.192
1,250	14.5	0.196
1,300	14.8	0.198
1,350	14.9	0.198
1,400	14.9	0.197
1,450	14.9	0.197
1,500	15.0	0.197
1,550	15.2	0.198

**Table 7M
Nominal Coefficients of Thermal Conductivity and Thermal Diffusivity**

Temperature, °C	Thermal Conductivity, W/m × °C	Thermal Diffusivity, 10 ⁻⁶ m ² /s
20	9.3	2.70
50	10.0	2.86
75	10.7	3.00
100	11.3	3.12
125	11.8	3.21
150	12.2	3.28
175	12.6	3.35
200	13.0	3.41
225	13.5	3.49
250	14.1	3.57
275	14.7	3.66
300	15.3	3.74
325	15.9	3.83
350	16.4	3.92
375	16.9	4.00
400	17.4	4.09
425	17.9	4.17
450	18.3	4.25
475	18.8	4.33
500	19.4	4.40
525	20.1	4.46
550	20.9	4.52
575	21.7	4.59
600	22.6	4.68
625	23.5	4.79
650	24.3	4.92
675	25.0	5.02
700	25.5	5.10
725	25.7	5.12
750	25.8	5.10
775	25.8	5.12
800	25.8	5.06
825	26.0	5.08
850	26.3	5.11
875	26.6	5.16
900	27.0	5.21
925	27.3	5.26
950	27.6	5.29
975	27.9	5.33
1 000	28.2	5.36

Case 2795

Use of PTFE Tubing Material for Flue Gas Heat Exchanger Tubes

Section VIII, Division 1

Approval Date: March 18, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May polytetrafluoroethylene (PTFE) be used for flue gas heat exchanger tubes with water as the tube-side fluid and flue gas as the shell-side fluid in Section VIII, Division 1 construction? For the purpose of this Case, flue gas heat exchangers are used downstream of the boiler and electrostatic precipitator in a power plant.

Reply: It is the opinion of the Committee that PTFE may be used for flue gas heat exchanger tubes in Section VIII, Division 1 construction, provided the following requirements are met.

1 GENERAL REQUIREMENTS

(a) The virgin PTFE material shall have no fillers, additives, or pigments and shall be in compliance with ASTM D4895-10 and shall be limited to the polymer with a classification designation of either Type I Grade 4 Class B, or Type I Grade 3 Class D. The PTFE material shall also have a stretching void index of 50 maximum and a thermal instability index of 7 maximum. The PTFE fine powder material shall be certified by the materials manufacturer, and a certificate of analysis shall be furnished to the vessel manufacturer for each batch of finished material from a production reactor.

(1) The resin manufacturer's certificate of analysis shall include the following as a minimum with the referenced ASTM D4895-10 standard.

(-a) name and address of production plant where the material was made

(-b) reactor batch number (Batch is defined as the finished capacity of the reactor producing the material during one production cycle.)

(-c) certification of conformance with applicable ASTM D4895-10 type, grade, and class

(-d) apparent bulk density

(-e) average particle size diameter

(-f) standard specific gravity of material

(-g) thermal instability index

(-h) stretching void index

(2) The tube manufacturer's certified material test report shall include the following recorded data as a minimum.

(-a) name and address of production plant where tubes were made.

(-b) lot number for each extruder run (An extruder run is the length of tubing produced by the extruder in one production cycle and is given a unique serial number, which is the lot number by the tubing manufacturer.)

(-c) reference to resin manufacturer's batch number from which the tubes were made and ASTM specification, type and grade, and class

(-d) total length of lot

(-e) number of tubes cut from the lot coil and their nominal lengths

(-f) design drawing number and revision showing tube dimensions

(-g) outside diameter and nominal thickness of tubes

(-h) centerline U-bend radius for each tube referenced to tube serial number

(-i) specific gravity of extruder lot per ASTM D792-08

(-j) visual inspection results per [Table 1](#) and dimensions (O.D. and wall thickness) with reference tolerances for each tube

(-k) test pressure per [3\(d\)](#) after bending and its duration for the lot and certification of acceptable results

(-l) manufacturer's written tubing production procedure number

(-m) extrusion pressure at applicable reduction ratio

(b) The tube side of the completed heat exchanger shall be limited to liquid water service. Any service classified per UW-2(a) is not allowed.

(c) The maximum allowable design pressure for the tube side of the heat exchanger shall be limited to 116 psi (800 kPa) at a maximum temperature of 325°F (163°C).

(d) The PTFE tubing shall not be subject to any differential external pressure. The exchanger shall be installed in a system that controls the operation to ensure the tube design pressure and temperature are not exceeded (e.g., maximum tube temperature exceeded due to loss of water on the tube side).

(e) The shell side of the tubes shall be not be subjected to a flue gas temperature exceeding 383°F (195°C), which shall also be the design temperature of the tube wall and the shell side of the exchanger. The minimum tube design temperature shall be no colder than 40°F (4.4°C). The design pressure of the shell side of the exchanger shall be less than 15 psig (103 kPa).

(f) The maximum nominal outside diameter of the PTFE tubing shall not exceed 0.63 in. (16 mm) with a minimum wall thickness of 0.035 in. (0.89 mm). The tolerance on outside diameter shall be $\pm 1\%$ and on nominal wall thickness $+0.012/-0$ in. ($+0.3/-0$ mm).

(g) The heat exchanger shall be limited to a vertically oriented U-tube type with the U-bends at the bottom of the exchanger, and this service restriction shall be noted in the Remarks section of the Manufacturer's Data Report.

(h) The minimum centerline radius of the U-bends shall be four times the outside diameter of the tubing.

(i) Repairs to the PTFE tubing shall not be permitted.

(j) The PTFE tubing shall be mechanically attached to a metallic tubesheet using qualified procedures and operators per 2(e) and pull-tested per 4(c)

(k) The PTFE tubing shall be marked with an attached identification tag having a unique serial number on an end that will be trimmed off during installation into the tubesheet to provide traceability to the tubing material manufacturer's report of test results as well as the raw material supplier's certificate of analysis. The tubing manufacturer shall provide a map showing the location of each tagged tube into the tubesheet.

(l) The tubing shall be manufactured using paste extrusion process in which a virgin PTFE fine powder is mixed with a volatile hydrocarbon type lubricant pressed using a hydraulic ram into a cylindrical preform shape and fed into an extruder. This process shall be controlled by a written procedure in which all of the following process variables shall be considered essential:

(1) blend preparation

(-a) lubricant type and percentage based on total weight %

(2) extrusion parameters

(-a) tooling size, die and tip, in. (mm)

(-b) reduction ratio (ratio of cross-sectional area of the resin in the extruder barrel to the cross-sectional area of the resin in the die land)

(-c) tooling temperature, °F (°C)

(-d) drying oven temperature, °F (°C)

(-e) sintering oven temperature, °F (°C)

(-f) tube speed, ft/min (m/min)

A change in any of the essential variables shall require requalification of the written procedure per the test procedure specified in sections 2 and 3 below. The procedure shall indicate acceptable ranges for items (1)(-a) and (2)(-c) through (2)(-f). The tube manufacturer shall also certify that the extruder lot of tubing meets the requirements of this Case.

(m) Tubing used for qualification testing shall not be used on Code-stamped heat exchangers.

(n) The design of the tubing shall take into account published cold flow data for PTFE to ensure the tubes do not permanently lengthen or expand under pressure or their own weight plus the weight of liquid and the differential longitudinal pressure stress in them. To ensure cold flow or creep is not an issue, the total longitudinal stress shall be limited to 600 psi (4.1 MPa) at the design temperature of the tube side of the exchanger. The total longitudinal stress due to pressure and weight shall be determined using the formulas in 5(b).

(o) The use of regrind or recycled material is prohibited.

(p) The completed tube side of the heat exchanger shall be hydrostatically tested per UG-99(b) at 1.3 times the MAWP of the tube side.

NOTE: Since the tube side contains carbon steel components, the lowest stress ratio will be 1.0 at the design temperature.

(q) This Case number shall be shown on the Manufacturer's Data Report and marked on the tubing identification tag, all material test reports, and the Code nameplate.

(r) On Form U-1, line 13 the description of the tubes shall be PTFE per ASTM D4895 with type, grade, and class to which it was manufactured listed.

2 DESIGN QUALIFICATION

The maximum allowable working pressure (which shall equal the design pressure) of the PTFE tubing shall be established by the following procedure.

(a) Long-term hydrostatic strength testing shall be conducted in accordance with ISO 9080-12 or ASTM D2837-11. The testing laboratory shall be accredited by the American Association for Laboratory Accreditation (A2LA) in the U.S.A, or shall be accredited by another agency recognized by the local jurisdiction elsewhere. The laboratory shall be qualified per ISO 17025 to perform this type of testing. The testing shall be conducted on a representative sample of a reactor batch of the virgin resin and of the extrusion lot to be used in actual production tubes using air or nitrogen as the test fluid. These tests shall be conducted at ambient, an intermediate temperature and up to 36°F (20°C) above the design temperature for a period of 10,000 hr and use linear regression analysis to extrapolate the long term strength for 50 yr per ISO 9080 or 100,000 hr per ASTM D2837.

The long-term hydrostatic strength at the design temperature obtained shall have a design factor of 0.67 applied resulting in a design strength that does not exceed $\frac{2}{3}$ of the yield strength. The ratio of the lower confidence limit strength to the long term hydrostatic strength shall be a minimum of 0.9 for each method.

(b) The Authorized Inspector (AI) shall verify that the certified long-term hydrostatic strength test has been completed.

(c) The design qualification tubing shall be visually examined for imperfections prior to having samples subjected to the long-term hydrostatic testing. Classification and acceptance level of imperfections shall be according to Table 1.

(d) The rules of 5(a) of this Case shall be used to calculate the hoop stress in the tube at any pressure.

(e) Mechanical designs for the tube-to-tubesheet joint must have a written joining procedure and have a tube pull out test per 4(c). The tube-to-tubesheet joining procedure shall include procedure specifications, performance qualifications, acceptance criteria, and a procedure for how workers joining tubes to tubesheets shall be qualified. The procedure shall be acceptable to the AI and the user.

3 PRODUCTION TUBES

(a) Each tubing extruder run or lot shall be examined by the tube manufacturer externally over its entire length for imperfections. Classification and acceptance level of imperfections shall be according to Table 1. Any defective area found larger than the maximum allowable size shall be removed in its entirety.

(b) A sample of each production extruder lot shall have its specific gravity determined in accordance with ASTM D792-08 and shall have a value of 2.13 to 2.16.

(c) All tubes in a production extruder lot shall be examined for conformance with dimensions and tolerances shown on the design drawings or given in the ASTM D3295-06 Group 03, whichever is more restrictive. Any dimension falling outside the specified limit or the tolerances of this Case shall require the defective section to be rejected, cut out, and not used.

(d) After the tube manufacturer bends the tubes, they shall be subjected to a minimum hydrostatic pressure test of 70% of the burst pressure at the tube manufacturer with water at $70^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ($21^{\circ}\text{C} \pm 3^{\circ}\text{C}$) for a minimum hold time of 15 min. Any failure due to burst, visible deformation, or leakage shall reject that specific tube. Retesting is not permitted.

4 PRODUCTION QUALIFICATION

(a) At least one tube per 65,000 ft (20,000 m) or at least one tube per bundle, whichever is less, shall be subject to a cold and hot burst test by the exchanger manufacturer in accordance with the following procedures. These tests shall be witnessed by the AI and certified by the manufacturer.

(1) Cold Burst Pressure Test

(-a) Cut five 10 in. $\pm 1/16$ in. (250 mm ± 2 mm) long samples from the test tube.

(-b) Condition the tubes for at least 4 hr at $73^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ($23^{\circ}\text{C} \pm 2.8^{\circ}\text{C}$) prior to testing. The test fluid temperature shall also be at this temperature.

(-c) Measure the wall thickness and outer diameter and record these values on the manufacturer's quality control form.

(-d) Close one end of the tube with a compression plug fitting and install a fill fitting on the other end. Fill the samples with mineral oil or water and plug the fill fitting. Make sure no visible air bubbles are present in the tube.

(-e) Raise the pressure of the fluid at a maximum rate of 145 psig/min (1 MPa/min) to 203 psig (1.4 MPa), and hold for a minimum of 6 min.

(-f) Then raise the pressure at a maximum rate of 29 psi/min (200 kPa/min) until the tube bursts. If the end plug leaks or fails before the tube bursts or leaks, the test is not valid.

(-g) Record the burst pressure at the end of the test as well as all test conditions.

(-h) The burst hoop stress shall have a minimum value of 1,914 psi (13.2 MPa) for any of the samples, which shall be calculated per 5(a).

(2) Hot Burst Pressure Test

(-a) Cut five 6 in. $\pm 1/16$ in. (150 mm ± 2 mm) long samples from the test tube.

(-b) Measure the wall thickness and outer diameter and record these values on the manufacturer's quality control form.

(-c) Close one end of the tube with a compression plug fitting.

(-d) Fill each tube to 75% of its volume with water (the rest is air) at a minimum temperature of 60°F (15°C).

(-e) Close the open end of the tube with a plug fitting.

(-f) Install oven thermocouples onto the tubes.

(-g) Heat the tubes in an oven preheated at $320^{\circ}\text{F} \pm 4^{\circ}\text{F}$ ($160^{\circ}\text{C} \pm 2^{\circ}\text{C}$) in a way that they are visible once the door is closed.

(-h) Condition the tubes for 15 min at the preheated temperature.

(-i) Raise the temperature at a maximum rate of $5.4^{\circ}\text{F}/\text{min}$ ($3^{\circ}\text{C}/\text{min}$) until all tubes burst or leak. If the end plug leaks or fails before the tube bursts or leaks the test is not valid.

(-j) Record the temperature during the whole test including rate of temperature rise.

(-k) Note the burst or leak temperature of each tube and record it on the certified test report.

(-l) The steam pressure at burst can be calculated using the steam pressure table of water.

(-m) The burst hoop stress shall be calculated per 5(a) and have a minimum value of 710 psi (4.9 MPa) for any of the samples.

(b) The tubing to be used for these tests shall be selected at random by the AI, and the test results shall be certified by the manufacturer on their material test report.

(c) In addition to meeting the procedure performance qualifications of 2(e) for tube-to-tubesheet joints, and before making production tube-to-tubesheet joints, each worker shall demonstrate to the satisfaction of the AI the ability to achieve complete tube-to-tubesheet joints by successfully assembling six test pieces with a minimum joint pull-out strength that exceeds the strength of the bare tube. The test pieces shall be visually examined to verify a complete joint, sectioned to verify minimum required tube thickness and complete compression of the tube along the entire length of the joint. For each worker's mock-up assembly, a tube pull test shall be done for each size and thickness of tube being used using six tubes in a tubesheet mockup. The tube pull-out test shall establish that the tubes will fail outside the tubesheet before the tube-to-tubesheet joint fails. The results shall be recorded and maintained with the performance qualification record. The results for each worker shall be acceptable to the AI before that worker performs any production tube-to-tubesheet joints.

5 TUBE STRESS CALCULATIONS

(a) The hoop stress in the tubing at any pressure [see 2(d), 4(a)(1)(-h), and 4(a)(2)(-m)] shall be calculated based on the following equation for internal pressure.

$$S_h = Pr/t \quad (1)$$

where

- P = internal pressure
- r = maximum inside radius of the tube
- S_h = hoop stress value at pressure P
- t = minimum thickness of the tube

(b) The longitudinal stress in the tubing at pressure P [see 1(n)] and total longitudinal stress shall be calculated based on the following equations:

$$S_{lp} = Pr/2t \quad (2)$$

where

- S_{lp} = longitudinal stress value at pressure P

$$S_l = S_{lp} + W/A \quad (3)$$

where

- A = cross sectional area of the tubing
- S_l = total longitudinal stress due to pressure and weight
- W = weight of suspended tubing below the tubesheet plus the weight of the water contained in the suspended tube

P , r , and t are defined in (a).

6 PHYSICAL PROPERTIES

Select physical properties for PTFE to be used for design are as follows:

(a) thermal conductivity = 0.14 Btu/hr-ft-°F (0.25 W/m-K)

(b) linear coefficient of expansion from 77°F to 392°F (25°C to 200°C) = 8.4×10^{-5} in./in. °F (15.1×10^{-5} mm/mm °C)

7 SUMMARY OF CODE CASE REQUIREMENTS

Table 2 provides a summary of the Code Case requirements for material, design, and qualification.

Table 1
Visual Flaw Acceptance Criteria

Defect	Definition	Maximum Size, in. (mm)
Black spots, brown streaks	Dark spots or streaks	0.015 (0.4)
Blisters	Hollows on or in the part	0.015 (0.4)
Bubbles	Air entrapped in the part	0.015 (0.4)
Burn marks, dieseling	Charred or dark plastic caused by trapped gas	0.015 (0.4)
Cracking, crazing	Any visible	0.015 (0.4)
Delamination	Single surface layers that flake off the part	0.015 (0.4)
Discoloration	Similar to burn marks but generally not as dark or severe	Acceptable
Flow, halo, blush marks	Marks seen on the part due to flow of molten plastic across the molding surface	0.015 (0.4)
Gels	Bubbles or blisters on or in the part due to poor melt quality	0.015 (0.4)
Jetting	Undeveloped frontal flow	0.015 (0.4)

Table 2
Summary of Material, Design, and Qualification Requirements

Requirement	Paragraph	Comment
Material specification	1(a)	Resin raw material
Minimum wall thickness	1(f)	...
Maximum O.D.	1(f)	...
Extrusion process and procedure qualification	1(l)	Qualified procedure required
Tube side design pressure (internal and external)	1(c) and 1(d)	...
Tube side temperature	1(c)	...
Maximum shell side design pressure	1(e)	...
Maximum design temperature of shell side	1(e)	...
Maximum design temperature of tubes	1(e)	...
Tube configuration and orientation	1(g)	Vertical U-tube only
Maximum longitudinal tube stress	1(n)	...
Minimum bend radius	1(h)	...
Tube-to-tubesheet joint	1(j), 2(e), and 4(c)	...
Tube side hydrostatic test pressure	1(p)	...
Design pressure qualification	2(a)	Long term hydrostatic tests
Production qualifications	4(a) and 4(c)	Hot and cold burst tests and pullout tests
Tube stress calculation formulas	5(a) and 5(b)	Hoop and longitudinal Stress
Material physical properties	6(a) and 6(b)	...

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Case 2797

Material Requirements for Valve Stems for Use With Power-Actuated Pressure Relief Systems

Section VIII, Division 3

Approval Date: March 18, 2014

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the materials requirements of Section VIII, Division 3, KR-324 be used for the stems of valves used in conjunction with power-actuated pressure relief systems that meet the requirements of Article KR-6?

Reply: It is the opinion of the Committee that materials meeting the requirements of Section VIII, Division 3, KR-324 may be used for the stems of valves used in conjunction with power-actuated pressure relief systems that meet the requirements of Article KR-6, provided the following requirements are met:

(a) Failure of the valve stem shall result in depressurization of the system.

(b) Any fluid that is released as a result of valve stem failure shall be directed away from personnel.

(c) Fluid released shall be nonhazardous.

(d) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2798

Welding Filler Metals

Section II, Part C

Approval Date: April 1, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the welding electrodes and filler metals shown in AWS A5.11/A5.11M:2010, Specification for Nickel and Nickel-Alloy Electrodes for Shielded Metal Arc Welding, which has been approved for publication by ASME without any changes but not yet published, be used?

Reply: It is the opinion of the Committee that the welding electrodes and filler metals shown in AWS A5.11/A5.11M:2010, Specification for Nickel and Nickel-Alloy Electrodes for Shielded Metal Arc Welding, may be used under the following conditions:

(a) ENiCrFe-13 and ENiCrMo-22 shall be considered F-No. 43 in Section IX, Table QW-432.

(b) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2799-1

Induction Kinetic Welding

Section VIII, Division 1; Section VIII, Division 2; Section IX

Approval Date: June 26, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a WPS be qualified for using induction kinetic welding to circumferentially butt weld pipe?

Reply: It is the opinion of the Committee that a WPS may be qualified for using induction kinetic welding to circumferentially butt weld pipe, provided the following conditions are met:

(a) Welding Procedure Specification (WPS) Qualification

(1) The WPS shall be limited to circumferential butt welding of pipe with the same nominal wall thickness and outside diameter.

(2) The WPS shall be qualified by preparing a qualification weld, observing, and recording the values for the variables from Table 1 with the following three additional essential variables:

(-a) a change in induction coil power greater than 3%

(-b) a change in induction heating time greater than 10%

(-c) a change in the cumulative rotational distance of motion greater than 10%

(3) The completed weld shall be visually examined according to QW-144, and the weld reinforcement shall have a gradual transition from the pipe to the weld on both the outside diameter and inside diameter surface.

(4) The completed test coupon shall be subjected to the mechanical tests required by Table QW-451.1.

(b) The welding operator qualification for induction kinetic welding shall be in accordance with QW-305.

(c) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Welding Variables for Induction Kinetic Welding

Paragraph	Subparagraph	Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-402, Joints	.12(a)	∅ ±10 deg	X	...	...
	.12(b)	∅ Cross-section > 10%	X	...	...
	.12(c)	∅ O.D. > ±10%	X	...	...
QW-403, Base Metals	.24	∅ Specification, type, or grade	X	...	...
QW-406, Preheat	.7	∅ > 10% Amperage or number of preheat cycles or method, or > 25°F temperature	X	...	...
QW-407, PWHT	.8	∅ PWHT, PWHT cycles, or separate PWHT time or temperature	X	...	...
QW-408, Gas	.22	∅ Shielding gas composition, pressure, or purge time	X	...	...
QW-410, Technique	.17	∅ Type/model of equipment	X	...	...
	.27	∅ Spp. > ±10%	X	...	...
	.31	∅ Cleaning method	X	...	...
	.54	∅ > 10% Upset length or force	X	...	...
	.55	∅ > 10% Distance between clamping dies or preparation of clamping area	X	...	...
	.57	∅ > 10% Forward or reverse speed	X	...	...

Legend:

∅ = Change

Case 2801-2

Alloy SUS 430J1LTB/JIS G 3463:2006 Tubes for Heating Boilers

Section IV

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may alloy SUS 430J1LTB meeting the material requirements of JIS G 3463:2006 be used in the construction of heating boilers per Part HF?

Reply: It is the opinion of the Committee that alloy SUS 430J1LTB meeting the material requirements of JIS G 3463:2006¹ may be used in the construction of heating boilers per Part HF, provided the following requirements are met:

(a) The allowable stress values for tubes in accordance with alloy SUS 430J1LTB shall be as listed in [Tables 1](#) and [1M](#).

(b) The minimum specified tensile strength shall be 56.5 ksi (390 MPa).

(c) The minimum specified yield strength shall be 29.5 ksi (205 MPa).

(d) For the purpose of welding and brazing procedure and performance qualifications, this material shall be considered P-No. 7, Group No. 2 for welding and P-No. 102 or AWS B2.2/B2.2M, BM 150 for brazing.

(e) For external pressure, Figure CS-2 of Section II, Part D shall be used.

(f) All other requirements of Section IV shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	11.3
150	11.2
200	11.1
250	10.9
300	10.8
400	10.7
500	10.4

GENERAL NOTES:

- (a) This material may utilize the minimum thickness exemptions shown in HF-301.1(c).
 (b) For welded tubes and pipes, a quality factor of 0.85 shall be applied.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	78.0
65	78.0
100	75.9
150	74.5
200	73.7
225	73.1
250	72.3
275 [Note (1)]	71.4

GENERAL NOTES:

- (a) This material may utilize the minimum thickness exemptions shown in HF-301.1(c).
 (b) For welded tubes and pipes, a quality factor of 0.85 shall be applied.

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

¹ See Section II, Part A, Nonmandatory Appendix A in order to obtain an English copy of the specification.

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Case 2802-2

Alloy SUS 430J1LTB/JIS G 3463:2006 Tubes for Water Heaters

Section IV

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may alloy SUS 430J1LTB meeting the material requirements of JIS G 3463:2006 be used in the construction of water heaters per Section IV, Part HLW?

Reply: It is the opinion of the Committee that alloy SUS 430J1LTB meeting the material requirements of JIS G 3463:2006¹ may be used in the construction of water heaters per Section IV, Part HLW, provided the following requirements are met:

(a) The allowable stress values for tubes in accordance with alloy SUS 430J1LTB shall be as listed in [Tables 1](#) and [1M](#).

(b) The minimum specified tensile strength shall be 56.5 ksi (390 MPa).

(c) The minimum specified yield strength shall be 29.5 ksi (205 MPa).

(d) For the purpose of welding and brazing procedure and performance qualifications, this material shall be considered P-No. 7, Group No. 2 for welding and P-No. 102 or AWS B2.2/B2.2M, BM 150 for brazing.

(e) For external pressure, Figure CS-2 of Section II, Part D shall be used.

(f) All other requirements of Section IV shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	14.1
150	14.0
200	13.8
250	13.7
300	13.5
400	13.3
500	13.1

GENERAL NOTE: For welded tubes and pipes, a quality factor of 0.85 shall be applied.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	97.5
65	97.5
100	94.9
150	93.2
200	92.1
225	91.4
250	90.4
275 [Note (1)]	89.3

GENERAL NOTE: For welded tubes and pipes, a quality factor of 0.85 shall be applied.

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

¹ See Section II, Part A, Nonmandatory Appendix A in order to obtain an English copy of the specification.

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Case 2803

Use of Thermometers With Minimum Full-Scale Range of 50°F to 250°F (10°C to 120°C)

Section IV

Approval Date: May 19, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May thermometers with a minimum full-scale range of 50°F to 250°F (10°C to 120°C) be used on Section IV boilers?

Reply: It is the opinion of the Committee that thermometers with a minimum full-scale range of 50°F to 250°F (10°C to 120°C) may be used on Section IV boilers under the following conditions:

(a) These thermometers shall not be used after December 31, 2015.

(b) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2804

Corrected Forming Strain Equation, Table 6.1

Section VIII, Division 2

Approval Date: June 23, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it the intent of Section VIII, Division 2 that the forming strain equation in Table 6.1 use the term D_o in the denominator applicable for all one-piece double-curved circumferential products?

Reply: It is the opinion of the Committee that the current equation for all one-piece double-curved circumferential products in the first row of Table 6.1 is incorrect, and the following corrected equation shall be used:

$$\varepsilon_f = 100 \ln \left(\frac{D_b}{D_f - 2t} \right)$$

where

D_b = diameter of blank plate or of intermediate product

D_f = final outside diameter of component after forming

t = nominal thickness of plate, pipe, or tube before forming

ε_f = calculated forming strain

This Case number shall be shown on the Manufacturer's Data Report.

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Case 2805

Alternate Rules to PG-26 for Nickel Base Alloys

Section I

Approval Date: May 14, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternate rules to PG-26, Section I may be used for determining the weld strength reduction factors (WSRFs) to be applicable when calculating maximum allowable working pressure (MAWP) or minimum required thickness of components fabricated with longitudinal and spiral (helical) seam welds made from nickel base alloys not listed in PG-26 and used in the creep range?

Reply: It is the opinion of the Committee that the rules of PG-26 and Table PG-26 [excluding Note (4)] and described in the Inquiry shall apply, provided the following requirements are met:

(a) Nickel base alloys [see (d)] not listed in PG-26 but listed in Section II, Part D, Table 1B and applicable code cases for Section I components are shown in Table 1 along with assigned WSRFs. These alloys and their assigned WSRFs are covered by the rules in this Case when welded with or without filler.

(b) Autogenous welds (made without weld filler metal) made from nickel base alloys listed in (a) have been assigned a WSRF of 1.00 up to 1,650°F (899°C) when stress allowables are provided in Section II, Part D, Table 1B or applicable code cases, and provided that the product is solution annealed after welding and receives a nondestructive electric examination in accordance with the material specification.

(c) WSRFs shall be applied in the design of cylinders containing longitudinal butt welds and to hemispherical heads or any other spherical sections that comprise segments joined by welding. Longitudinal butt welds shall be interpreted to include spiral (helical) welds per PW-11.2.

(d) Nickel base alloys are defined as metal alloys that contain more nickel by weight percent than any other element.

(e) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
WSRFs to Be Applied When Calculating MAWP of Minimum Required Thickness of Components Fabricated with Longitudinal Seam Weld

Temperature		Nickel Base Alloys												Autogenous Welded Nickel Base Alloys
°F	°C	N06045	N06600	N06690	N06601	N06025	N10276	N06022	N06230	N06625	N06617 (Except SAW) [Note (1)]	N06617 (SAW) [Note (2)]	N07740	
700	371	...	...	...	...	...	...	...	...	...	...	...	...	...
750	399	...	...	...	...	...	...	...	...	...	...	...	...	...
800	427	1.00	1.00	...	...	...	...	...	...	...	...	...	...	1.00
850	454	0.95	0.95	1.00	...	...	...	...	...	...	...	...	...	1.00
900	482	0.91	0.91	0.95	1.00	...	...	...	...	...	...	...	...	1.00
950	510	0.86	0.86	0.91	0.95	1.00	1.00	...	...	...	...	...	...	1.00
1,000	538	0.82	0.82	0.86	0.91	0.95	0.95	1.00	1.00	...	...	...	...	1.00
1,050	566	0.77	0.77	0.82	0.86	0.91	NP	0.95	0.95	...	...	...	...	1.00
1,100	593	0.73	0.73	0.77	0.82	0.86	NP	0.91	0.91	1.00	1.00	1.00	1.00	1.00
1,150	621	0.68	0.68	0.73	0.77	0.82	NP	0.86	0.86	0.95	1.00	0.80	0.70	1.00
1,200	649	0.64	0.64	0.68	0.73	0.77	NP	0.82	0.82	0.91	1.00	0.80	0.70	1.00
1,250	677	0.59	NP	NP	0.68	0.73	NP	0.77	0.80	NP	1.00	0.80	0.70	1.00
1,300	704	0.55	NP	NP	0.64	0.68	NP	NP	0.80	NP	1.00	0.80	0.70	1.00
1,350	732	0.50	NP	NP	0.59	0.64	NP	NP	0.80	NP	1.00	0.80	0.70	1.00
1,400	760	0.50	NP	NP	0.55	0.59	NP	NP	0.80	NP	1.00	0.80	0.70	1.00
1,450	788	0.50	NP	NP	0.50	0.55	NP	NP	0.80	NP	1.00	0.80	0.70	1.00
1,500	816	0.50	NP	NP	0.50	0.50	NP	NP	0.80	NP	1.00	0.80	0.70	1.00
1,550	843	NP	NP	NP	0.50	0.50	NP	NP	0.80	NP	1.00	0.80	NP	1.00
1,600	871	NP	NP	NP	0.50	0.50	NP	NP	0.80	NP	1.00	0.80	NP	1.00
1,650	899	NP	NP	NP	0.50	0.50	NP	NP	0.80	NP	1.00	0.80	NP	1.00

Legend:

NP = Not permitted

NOTES:

(1) Includes SMAW, GTAW, and GMAW filler metal welds.

(2) SAW filler metal welds.

Case 2806

Rules for Calculating Maximum Permissible Gaps for Layered Vessels in 4.13.12.3

Section VIII, Division 2

Approval Date: June 23, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the following equation for K_c taken from AF-815.2 (2006 Addenda) be used instead of eq. (4.13.7) in 4.13.12.3 of Section VIII, Division 2 (2007 edition through 2013 edition)?

$$K_c = \left(\frac{4S_a}{3S_m} + 0.25 \right)^{0.5} - 0.5$$

Reply: It is the opinion of the Committee that the above equation may be used instead of eq. (4.13.7) in 4.13.12.3, provided that this Case number is shown on the Manufacturer's Data Report.

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Case 2807-1

Exemption From Post-Bending Heat Treatment Requirements for Carbon and Low-Alloy Steel Tube and Pipe

Section VIII, Division 1

Approval Date: December 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may bends in tube and pipe of carbon and low-alloy steel that are fabricated by cold forming be exempt from the post-bending heat treatment requirements of UCS-79(d)?

Reply: It is the opinion of the Committee that bends in tube and pipe of carbon and low-alloy steel that are fabricated by cold forming may be exempt from the post-

bending heat treatment requirements of UCS-79(d), provided the following requirements are met:

(a) For P-No. 1 material, the nominal wall thickness shall not exceed $\frac{3}{4}$ in. (19.0 mm).

(b) For carbon and low-alloy pipe and tube material in P-No. 3 through P-No. 5A, 5B Grade 1, and 5C Grade 1, an outside diameter is not greater than 4.5 in. (114 mm) and wall thickness not greater than $\frac{1}{2}$ in. (13.0 mm).

(c) This Case number shall be identified in the Manufacturer's Data Report.

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Case 2808-1

UNS S31254 and UNS N08904 Austenitic Stainless Steel Plate, Sheet, and Strip

Section VIII, Division 2

Approval Date: April 29, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use UNS S31254 and UNS N08904 plate, sheet, and strip conforming to the requirements of SA-240 for the construction of plate heat exchangers in accordance with Section VIII, Division 2?

Reply: It is the opinion of the Committee that plate, sheet, and strip described in the Inquiry may be used in the construction of plate heat exchangers in accordance of Section VIII, Division 2, provided the following requirements are met:

(a) The maximum allowable stress values for UNS S31254 shall be as listed in [Tables 1, 1M, 2 and 2M](#).

(b) The maximum allowable stress values for UNS N08904 shall be as listed in [Tables 3 and 3M](#).

(c) All other applicable requirements of Section VIII, Division 2 shall apply; use austenitic stainless steel rules for UNS S31254 and nickel alloy rules for UNS N08904.

(d) The maximum design temperature shall not exceed 750°F (399°C) for UNS S31254 and 700°F (371°C) for UNS N08904.

(e) This Case number shall be identified in the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for UNS S31254, Thickness Greater Than $\frac{3}{16}$ in.

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, ksi
-20 to 100	27.1
200	27.1
300	25.8
400	24.6
500	23.7
600	23.2
650	23.1
700	23.0
750	22.9

GENERAL NOTE: The allowable stress values are from Section II, Part D, Table 1A.

Table 1M
Maximum Allowable Stress Values for UNS S31254, Thickness Greater Than 5 mm

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, MPa
-30 to 40	187
65	187
100	186
125	183
150	178
200	170
250	164
300	161
325	160
350	159
375	158
400 [Note (1)]	158

GENERAL NOTE: The allowable stress values are from Section II, Part D, Table 1A.

NOTE: (1) The maximum design temperature is 399°C; the 400°C value is for interpolation only.

Table 2
Maximum Allowable Stress Values for UNS S31254,
Thickness Less Than or Equal to $\frac{3}{16}$ in.

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, ksi
-20 to 100	28.6
200	28.6
300	27.2
400	25.9
500	25.0
600	24.4
650	24.3
700	24.1
750	23.9

GENERAL NOTE: The allowable stress values are from Section II, Part D, Table 1A.

Table 2M
Maximum Allowable Stress Values for UNS S31254,
Thickness Less Than or Equal to 5 mm

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, MPa
-30 to 40	197
65	197
100	197
125	193
150	187
200	179
250	173
300	169
325	168
350	167
375	166
400 [Note (1)]	165

GENERAL NOTE: The allowable stress values are from Section II, Part D, Table 1A.

NOTE: (1) The maximum design temperature is 399°C; the 400°C value is for interpolation only.

Table 3
Maximum Allowable Stress Values for UNS N08904

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, ksi
-20 to 100	20.3
200	16.7
300	15.1
400	13.8
500	12.7
600	11.9
650	11.6
700	11.4

GENERAL NOTE: The allowable stress values are from Section II, Part D, Table 1B.

Table 3M
Maximum Allowable Stress Values for UNS N08904

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, MPa
-30 to 40	140
65	126
100	113
125	108
150	104
175	99.9
200	95.8
225	92.1
250	88.8
275	85.9
300	83.4
325	81.3
350	79.6
375 [Note (1)]	78.4

GENERAL NOTE: The allowable stress values are from Section II, Part D, Table 1B.

NOTE: (1) The maximum design temperature is 371°C; the 375°C value is for interpolation only.

Case 2809

58Ni-29Cr-9Fe Alloy (UNS N06690)

Section I

Approval Date: October 2, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May cold-drawn and annealed alloy UNS N06690, SB-167 seamless pipe and tube be used in water-wetted service in welded construction under Section I?

Reply: It is the opinion of the Committee that cold-drawn and annealed alloy UNS N06690, SB-167 seamless pipe and tube as described in the Inquiry may be used in water-wetted service in welded construction complying with the rules of Section I, provided the following requirements are met:

(a) The maximum allowable stress values for the material shall be those given in Section II, Part D, Table 1B.

(b) Welded fabrication shall conform to the applicable requirement of Section I. When welding is performed with filler metal of the same nominal composition as the base metal, only GMAW and GTAW processes are allowed.

(c) This base metal is assigned to P-No. 43.

(d) When heat treatment is applied, the temperature, time, and method of heat treatment shall be covered by agreement between the user and manufacturer. When this material is formed, the rules of Section I, PG-19 shall apply for alloy UNS N06690. Other than these requirements, any other heat treatment after forming or fabrication is neither required nor prohibited.

(e) For Section I, which requires a temperature-dependent parameter, y [see PG-27.4, Note (6)], the y values shall be as shown in PG-27.4.

(f) This Case number shall be recorded on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

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Case 2810

Use of UNS N08367 Material for Construction

Section I

Approval Date: October 2, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May annealed austenitic chromium-nickel-molybdenum-iron alloy UNS N08367 wrought sheet, strip, plate, rod and bar, flanges and fittings, and welded pipe and tubing be used for water-wetted service in Section I construction?

Reply: It is the opinion of the Committee that annealed austenitic chromium-nickel-molybdenum-iron alloy UNS N08367 wrought sheet, strip, plate, rod and bar, flanges and fittings, and welded pipe and tubing may be used for water-wetted service in Section I construction, provided the following requirements are met:

(a) Allowable product specifications are as shown in Table 1.

(b) The maximum service temperature is limited to 800°F (427°C).

(c) The maximum allowable stress values shall be those shown in Tables 2, 2M, 3, and 3M. Tables 2 and 2M are for SB-366, SB-675, SB-676, SB-688, SB-690, SB-691, SB-804 materials greater than $\frac{3}{16}$ in. (5 mm) thick and for SB-462 and SB-564 materials. Tables 3 and 3M are for SB-366, SB-675, SB-676, SB-688, SB-690, SB-691, SB-804 materials less than or equal to $\frac{3}{16}$ in. (5 mm) thick.

(d) The stresses for welded products shall be multiplied by a joint efficiency factor of 0.85.

(e) Welded fabrication shall conform to the applicable requirements of Section I.

(f) This base metal is assigned to P-No. 45.

(g) Welds that are exposed to the effects of corrosion shall be made using filler metal having corrosion resistance comparable to or better than that of the base metal.

(h) Heat treatment after forming or fabrication is neither prohibited nor required, but if performed shall be a full anneal per the material specification.

(i) The required thickness for external pressure shall be determined from Figure NFN-12 of Section II, Part D.

(j) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Allowable Product Specifications

Product Form	Specifications
Fittings	SB-366
Forgings	SB-462, SB-564
Plate, sheet, and strip	SB-688
Rod and bar	SB-691
Seamless pipe and tube	SB-690
Welded pipe	SB-675, SB-804
Welded tubing	SB-676

Table 2
Maximum Allowable Stress Values for UNS N08367,
Thickness Greater Than $\frac{3}{16}$ in.

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]
-20 to 100	27.1	27.1
200	26.2	27.1
300	23.8	25.7
400	21.9	24.6
500	20.5	23.8
600	19.4	23.3
650	19.0	23.1
700	18.6	22.9
750	18.3	22.8
800	18.0	22.6

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 2M
Maximum Allowable Stress Values for UNS N08367,
Thickness Greater Than 5 mm

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]
-30 to 40	187	187
65	185	187
100	179	186
125	172	182
150	164	177
175	157	173
200	152	170
225	147	167
250	143	165
275	139	163
300	136	161
325	133	160
350	130	159
375	128	158
400	126	157
425	124	156
450 [Note (2)]	122	155

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) The maximum design temperature is 427°C; the 450°C value is for interpolation only.

Table 3
Maximum Allowable Stress Values for UNS N08367,
Thickness Less Than or Equal to $\frac{3}{16}$ in.

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]
-20 to 100	28.6	28.6
200	26.2	28.6
300	23.8	27.0
400	21.9	25.8
500	20.5	25.0
600	19.4	24.5
650	19.0	24.3
700	18.6	24.1
750	18.3	24.0
800	18.0	23.8

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 3M
Maximum Allowable Stress Values for UNS N08367,
Thickness Less Than or Equal to 5 mm

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]
-30 to 40	197	197
65	189	197
100	179	197
125	171	192
150	164	186
175	157	181
200	152	178
225	147	176
250	143	173
275	139	171
300	136	170
325	133	168
350	130	167
375	128	166
400	126	165
425	124	164
450 [Note (2)]	122	163

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) The maximum design temperature is 427°C; the 450°C value is for interpolation only.

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Case 2811

SA/EN 10025-2 Steel Grades S235J2, S275J2, and S355J2

Section VIII, Division 1

Approval Date: November 14, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May steel grades S235J2, S275J2, and S355J2 as specified in SA/EN 10025-2 be used for the fabrication of pressure vessels if all other requirements of Section VIII, Division 1 are met?

Reply: It is the opinion of the Committee that the materials described in the Inquiry may be used in the construction of pressure vessels conforming to the rules of Section VIII, Division 1, provided the following requirements are met:

(a) The maximum allowable design stress shall not exceed that shown in [Table 1](#). Yield and tensile strength values used for design up to the maximum use temperature shall be the minimum values at room temperature as required by the specification.

(b) The maximum allowable design temperature shall not exceed 212°F (100°C).

(c) The thickness of the materials shall be limited between 0.20 in. to 0.55 in. (5 mm to 14 mm), inclusive.

(d) The materials shall be used for components under internal pressure only.

(e) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. Grades S235J2 and S275J2 shall be considered as P- No. 1, Group No. 1. Grade S355J2 shall be considered as P-No. 1, Group No. 2 for material thickness less than or equal to 4 in. (100 mm). Grade S355J2 shall be considered as P-No. 1, Group No. 1 for material thickness greater than 4 in. (100 mm).

(f) The materials shall be considered Curve B for the purpose of impact test requirements.

(g) The physical properties shall be those for carbon steels in Section II, Part D, Subpart 2.

(h) All other requirements in Part UCS shall be met.

(i) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F (°C)	Maximum Allowable Stress Values, ksi (MPa)		
	Steel Grade		
	S235J2	S275J2	S355J2
212 (100)	14.9 (103)	17.0 (117)	19.4 (134)

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Case 2812

Pneumatic Testing of Welded Hot Water Heating Boilers

Section IV

Approval Date: December 31, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may welded hot water heating boilers constructed in accordance with Section IV be tested pneumatically using the pressure differential method in lieu of the hydrostatic test required in HG-510(c)?

Reply: It is the opinion of the Committee that pneumatic testing using the pressure differential method may be used in lieu of hydrostatic test required in HG-510(c), provided the following requirements are met:

(a) The pressure change leak test shall be performed in accordance with the applicable requirements of Section V, Article 10, Mandatory Appendix VI and ASTM E2930.

(b) The volume of the welded boiler shall be no greater than 7 gal (26 L).

(c) No part of the tested item shall be made of cast materials.

(d) The MAWP shall be no greater than 80 psi (552 kPa).

(e) The test pressure shall be the greater of 38 psi or 1.1 times the MAWP.

(f) Heating boilers to be tested shall be compared to a reference vessel of proven leak-tight integrity to measure drop in pressure over time using an electronic control device.

(g) The heating boiler to be tested and the reference vessel shall be dry inside and outside with no visible signs of moisture.

(h) The heating boiler to be tested and the reference vessel shall be maintained at a minimum metal temperature of 60°F (16°C) during the test. In addition, the test boiler, reference vessel, and test air shall be maintained at a temperature that has no more than 5°F (3°C) difference among them.

(i) At a minimum, the written test procedure shall specify the following essential variables:

(1) acceptable air leakage rate that shall be used as a standard accept/reject criteria and that shall assure water tightness

(2) maximum acceptable metal temperature difference between the heating boiler to be tested and the reference vessel prior to testing

(3) volume of the heating boiler to be tested

(4) volume of the reference vessel

(5) time of stabilization

(6) time of test

(7) test pressure

(8) manufacturer and model name of test apparatus

(9) calibration periods

(10) personnel performance qualification

(j) The written test procedure shall be qualified by the Manufacturer and accepted by the AI prior to testing of any heating boilers. At a minimum, the procedure qualification shall meet the requirements referenced in (a). A change to any of the essential variables listed in (i) shall require re-qualification of the procedure.

(k) Personnel performing the test shall be trained to the written test procedure. Detailed requirements for procedure qualification and personnel qualification shall be included in the Manufacturer's written description of the quality control system.

(l) The test operator shall be isolated from the heating boiler and the reference vessel during the pressurized portion of test. Any observation shall be made from a safe location.

(m) This Code Case does not address all possible safety considerations associated with its use. It is the responsibility of the user of this Code Case to establish appropriate safety and health practices and to determine the applicability of any regulatory requirements or limitations prior to its use.

(n) The welded boiler shall meet all other requirements of Section IV.

(o) This Case number shall be shown on Manufacturer's Data Report.

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Case 2813

Laser Marking of Welded Hot Water Heating Boilers

Section IV

Approval Date: January 12, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may welded hot water heating boilers constructed in accordance with Section IV be marked by a Certificate Holder with the information including the Certification Mark using laser etching directly on the shell in lieu of the nameplate required in HG-530.1(d)?

Reply: It is the opinion of the Committee that laser etching used for marking of the information including the Certification Mark may be performed by a Certificate Holder in lieu of the nameplate required in HG-530.1(d), provided the following requirements are met:

(a) Laser marking shall be performed by the Manufacturer of the certified boiler.

(b) The material of the construction shall be limited to stainless steels.

(c) Laser etching shall be limited to welded boilers with the maximum nominal outside diameter equal to 18.9 in. (480 mm) or less.

(d) The arrangement and scope of data marked on the shell shall be in accordance with HG-530.1(a).

(e) The data shall be in characters not less than $\frac{5}{32}$ in. (4 mm) and shall be readable. The graphic image of the Certification Mark shall conform to the proportions of the official Certification Mark.

(f) The marking process shall leave a permanent and legible mark.

(g) The information marked on the shell shall not be covered by insulation or other material, unless the requirements of HG-530.1(e) are met.

(h) The process controls for laser marking shall be described in the Quality Control System and be acceptable to the Authorized Inspector.

(i) The welded boiler shall meet all other requirements of Section IV.

(j) This Case number shall be shown on Manufacturer's Data Report.

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Case 2814

Figure UW-13.4, Illustration (a)

Section VIII, Division 1

Approval Date: January 8, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In Section VIII, Division 1, Figure UW-13.4, illustration (a), under what conditions is a straight section at the end of the taper of the nozzle allowed?

Reply: It is the opinion of the Committee that in Figure UW-13.4, illustration (a), a straight section at the end of the taper of the nozzle is allowed, provided the following conditions are met:

(a) Length of the straight section with the minimum thickness equal to t_1 as defined in Figure UW-13.4, illustration (a) shall not exceed 0.875 in. (22 mm).

(b) The machining of the required taper shall be performed at the inside surface of the nozzle.

(c) The minimum thickness, t_1 , shall not be less than that required by the rules of UG-22, UG-27, UG-28, or Figure UW-13.4.

(d) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2815-1

Use of SA-336/SA-336M Class F91 for Class 2

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-336/SA-336M Class F91 be used for Section VIII, Division 2, Class 2 application?

Reply: It is the opinion of the Committee that SA-336/SA-336M Class F91 may be used for Section VIII, Division 2, Class 2 application, provided the following requirements are met:

(a) The maximum allowable stresses for SA-182/SA-182M Class F91 in Section II, Part D, Subpart 1, Table 5A shall be used for SA-336/SA-336M Class F91.

(b) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2816

Use of Ultrasonic Examination in Lieu of Radiography for Material Thickness Less Than $\frac{1}{2}$ in. (13 mm) But Greater Than or Equal to $\frac{1}{4}$ in. (6 mm)

Section I

Approval Date: January 8, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions and limitations may an ultrasonic examination be used to examine materials thinner than $\frac{1}{2}$ in. (13 mm) but thicker than or equal to $\frac{1}{4}$ in. (6 mm) in lieu of radiography, when volumetric examination is required in accordance with Section I, PW-11?

Reply: It is the opinion of the Committee that all welds in material ranging from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. (6 mm to 13 mm) in pressure vessels and power boilers may be examined using the ultrasonic (UT) method in lieu of the radiography (RT) method, provided that all of the following requirements are met:

(a) The ultrasonic examination area shall include the volume of the weld, plus 2 in. (50 mm) on each side of the weld. Alternatively, examination volume may be reduced to include the actual heat affected zone (HAZ) plus $\frac{1}{4}$ in. (6 mm) of base material beyond the heat affected zone on each side of the weld, provided the following requirements are met:

(1) The extent of the weld HAZ is measured and documented during the weld qualification process.

(2) The ultrasonic (UT) transducer positioning and scanning device is controlled using a reference mark (paint or low stress stamp adjacent to the weld) to ensure that the actual HAZ plus an additional $\frac{1}{4}$ in. (6 mm) of base metal is examined.

(b) A documented examination strategy or scan plan shall be provided showing transducer placement, movement, and component coverage that provides a standardized and repeatable methodology for weld acceptance. The scan plan shall also include ultrasonic beam angle used, beam directions with respect to weld centerline, and vessel volume examined for each weld. The documentation shall be made available to the Owner/User upon request.

(c) The ultrasonic examination shall be performed in accordance with a written procedure conforming to the requirements of Section V, Article 4.¹ The procedure shall have been demonstrated to perform acceptably on a qualification block(s). The qualification block(s) shall be prepared by welding or the hot isostatic process (HIP) and shall contain a minimum of three flaws, oriented to simulate flaws parallel to the production weld's fusion line as follows:

(1) one surface flaw on the side of the block representing the vessel O.D. surface

(2) one surface flaw on the side of the block representing the vessel I.D. surface

(3) one subsurface flaw

(4) If the block can be flipped during UT examination, then one flaw may represent both the I.D. and O.D. surfaces. Thus only two flaws may be required.

Flaw size shall be no larger than the flaw in [Table 1](#) for the thickness to be examined. Acceptable performance is defined as response from the maximum allowable flaw and other flaws of interest demonstrated to exceed the reference level. Alternatively, for techniques that do not use amplitude recording levels, acceptable performance is defined as demonstrating that all imaged flaws with recorded lengths, including the maximum allowable flaws, have an indicated length equal to or greater than the actual length of the flaws in the qualification block.

(d) The ultrasonic examination shall be performed using a device employing automatic computer based data acquisition. The initial straight beam material examination (T-472 of Section V, Article 4) for reflectors that could interfere with the angle beam examination shall be performed (1) manually, (2) as part of a previous

¹ Sectorial scans (S-scans) with phased arrays may be used for the examination of welds, provided they are demonstrated satisfactorily in accordance with para. (c). S-scans provide a fan beam from a single emission point, which covers part or all of the weld, depending on transducer size, joint geometry, and section thickness. While S-scans can demonstrate good detectability from side drilled holes, because they are omnidirectional reflectors, the beams can be misoriented for planar reflectors (e.g., lack of fusion and cracks). An adequate number of flaws should be used in the demonstration block to ensure detectability for the entire weld volume.

manufacturing process, or (3) during the automatic UT examination provided detection of these reflectors is demonstrated [subpara. (c)].

(e) Data is recorded in unprocessed form. A complete data set with no gating, filtering, or thresholding for response from examination volume in para. (a) above shall be included in the data record.

(f) Personnel performing and evaluating UT examinations shall be qualified and certified in accordance with their employer's written practice. ASNT SNT-TC-1A or CP-189 shall be used as a guideline. Only Level II or III personnel shall analyze the data or interpret the results.

(g) Contractor qualification records of certified personnel shall be approved by the Certificate Holder and maintained by their employer.

(h) In addition, personnel who acquire and analyze UT data shall be trained using the equipment in (d) above, and participate in the demonstration of (c) above.

(i) Data analysis and acceptance criteria shall be as follows:

(1) *Data Analysis Criteria.* Reflectors exceeding the limits in either (-a) or (-b) below, as applicable, shall be investigated to determine whether the indication originates from a flaw or is a geometric indication in accordance with para. (2) below. When a reflector is determined to be a flaw, it shall be evaluated for acceptance in accordance with para. (4), Flaw Evaluation and Acceptance Criteria.

(-a) For amplitude-based techniques, the location, amplitude, and extent of all reflectors that produce a response greater than 20% of the reference level shall be investigated.

(-b) For nonamplitude-based techniques, the location and extent of all images that have an indicated length greater than the limits in (-1) below, as applicable, shall be investigated.

(-1) Images with indicated lengths greater than 0.150 in. (3.8 mm) shall be investigated.

(2) *Geometric.* Ultrasonic indications of geometric and metallurgical origin shall be classified as follows:

(-a) Indications that are determined to originate from the surface configurations (such as weld reinforcement or root geometry) or variations in metallurgical structure of materials (such as cladding to base metal interface) may be classified as geometric indications, and

(-1) need not be characterized or sized in accordance with (3) below;

(-2) need not be compared to allowable flaw acceptance criteria of Table 1;

(-3) the maximum indication amplitude and location shall be recorded, for example: internal attachments, 200% DAC maximum amplitude, 1 in. (25 mm) above the weld centerline, on the inside surface, from 90 to 95 deg.

(-b) The following steps shall be taken to classify an indication as geometric:

(-1) Interpret the area containing the reflector in accordance with the applicable examination procedure;

(-2) Plot and verify the reflector coordinates, provide a cross-sectional display showing the reflector position and surface discontinuity such as root or counter-bore; and

(-3) Review fabrication or weld prep drawings.

(-c) Alternatively, other NDE methods or techniques may be applied to classify an indication as geometric (e.g., alternative UT beam angles, radiography, I.D. and/or O.D. profiling).

(3) *Flaw Sizing.* Flaws shall be sized in accordance with a procedure demonstrated to size similar flaws at similar material depths. Alternatively, a flaw may be sized by a supplemental manual technique so long as it has been qualified by the demonstration above. The dimensions of the flaw shall be determined by the rectangle that fully contains the area of the flaw. (Refer to Figures 1 through 5.)

(-a) The length of the flaw (ℓ) shall be drawn parallel to the inside pressure-retaining surface of the component.

(-b) The depth of the flaw shall be drawn normal to the inside pressure retaining surface and shall be defined as a for a surface flaw or $2a$ for a subsurface flaw.

(4) *Flaw Evaluation and Acceptance Criteria.* Flaws shall be evaluated for acceptance using the applicable criteria of Table 1 and with the following additional requirements:

(-a) *Surface Connected Flaws.* Flaws identified as surface flaws during the UT examination may or may not be surface connected. Therefore, unless the UT data analysis confirms that that flaw is not surface connected, it shall be considered surface connected or a flaw open to the surface, and is unacceptable unless a surface examination is performed in accordance with (-1), (-2), or (-3) below. If the flaw is surface connected, the requirements above still apply; however, in no case shall the flaw exceed the acceptance criteria in the applicable Construction Code for the method employed.

Acceptable surface examination techniques are:

(-1) Magnetic particle examination (MT) in accordance with Nonmandatory Appendix A, A-260 of Section I as applicable

(-2) Liquid penetrant examination (PT) in accordance with Nonmandatory Appendix A, A-270 of Section I as applicable

(-3) Eddy current examination (ET) in accordance with Supplement I of this Case. All relevant ET indications that are open to the surface are unacceptable regardless of length.

(-b) *Multiple Flaws*

(-1) Discontinuous flaws shall be considered a singular planar flaw if the distance between adjacent flaws is equal to or less than S as shown in Figure 2.

(-2) Discontinuous flaws that are oriented primarily in parallel planes shall be considered a singular planar flaw if the distance between the adjacent planes is equal to or less than $\frac{1}{2}$ in. (13 mm). (Refer to Figure 3.)

(-3) Discontinuous flaws that are coplanar and nonaligned in the through-wall thickness direction of the component shall be considered a singular planar flaw if the distance between adjacent flaws is equal to or less than S as shown in Figure 4.

(-4) Discontinuous flaws that are coplanar in the through-wall direction within two parallel planes $\frac{1}{2}$ in. (13 mm) apart (i.e., normal to the pressure-retaining surface of the component) are unacceptable if the additive flaw depth dimension of the flaws exceeds those shown in Figure 5.

(-c) *Subsurface Flaws*. Flaw length, ℓ , shall not exceed $4t$.

(j) The nameplate shall be marked under the Certification Mark by applying UT to indicate ultrasonic examination of welded seams required to be inspected in accordance with Section I.

(k) This Case number shall be shown on the Manufacturer's Data Report, and the extent of the UT examination shall be noted.

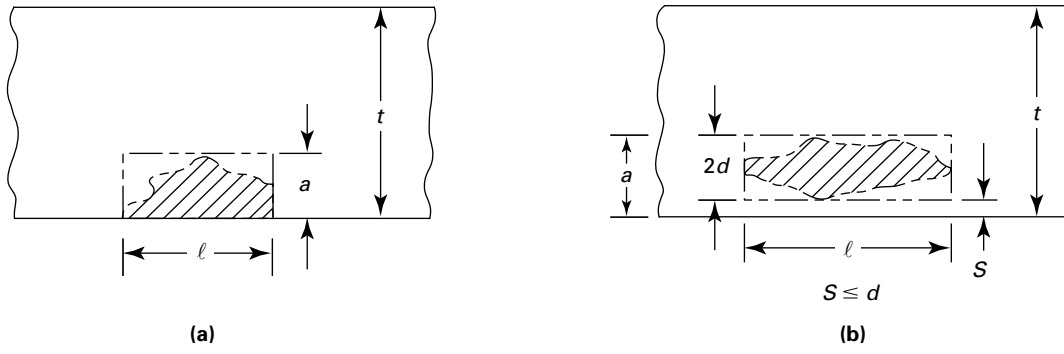
Table 1
Flaw Acceptance Criteria for Welds With Thickness
Between $\frac{1}{4}$ in. and $<\frac{1}{2}$ in. (6 mm and <13 mm)

Thickness, t in. (mm)	Surface Flaw, a in. (mm)	Subsurface Flaw, a in. (mm)	Length of Flaw, ℓ in. (mm)
$\frac{1}{4}$ (6)	0.040 (0.95)	0.020 (0.48)	$\leq \frac{1}{4}$ (≤ 6.4)
$\frac{3}{8}$ (10)	0.042 (1.04)	0.021 (0.52)	$\leq \frac{1}{4}$ (≤ 6.4)
$<\frac{1}{2}$ (<13)	0.044 (1.13)	0.022 (0.57)	$\leq \frac{1}{4}$ (≤ 6.4)

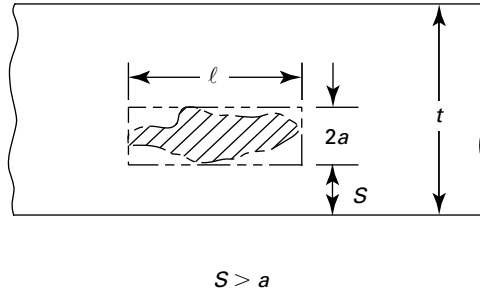
GENERAL NOTES:

- The parameter t is the thickness of the weld excluding any allowable reinforcement, and the parameter ℓ is the length of the flaw. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, then the thickness of the throat of the fillet weld shall be included in t .
- The acceptance limits specified here are based upon workmanship considerations and are not necessarily intended for use in evaluating flaws identified after the vessel has gone into service.
- Parameters a and ℓ are as defined in (i)(3)(-a) and (i)(3)(-b).
- For intermediate thicknesses of t [$\frac{1}{4}$ in. (6 mm) $< t < \frac{1}{2}$ in. (13 mm)], linear interpolation is permissible.
- The criteria for thickness $<\frac{1}{2}$ in. (<13 mm) is for interpolation of intermediate thicknesses only. See Code Case 2235 for the examination of material $\frac{1}{2}$ in. (13 mm) thickness or greater.
- A subsurface indication shall be considered as a surface flaw if the separation (S in Figure 1) of the indication from the nearest surface of the component is equal to or less than half the through dimension [$2d$ in Figure 1, illustration (b)] of the subsurface indication.

Figure 1
Single Indications



Surface Indications



(c) Subsurface Indications

Figure 2
Multiple Planar Flaws Oriented in Plane Normal to Pressure Retaining Surface

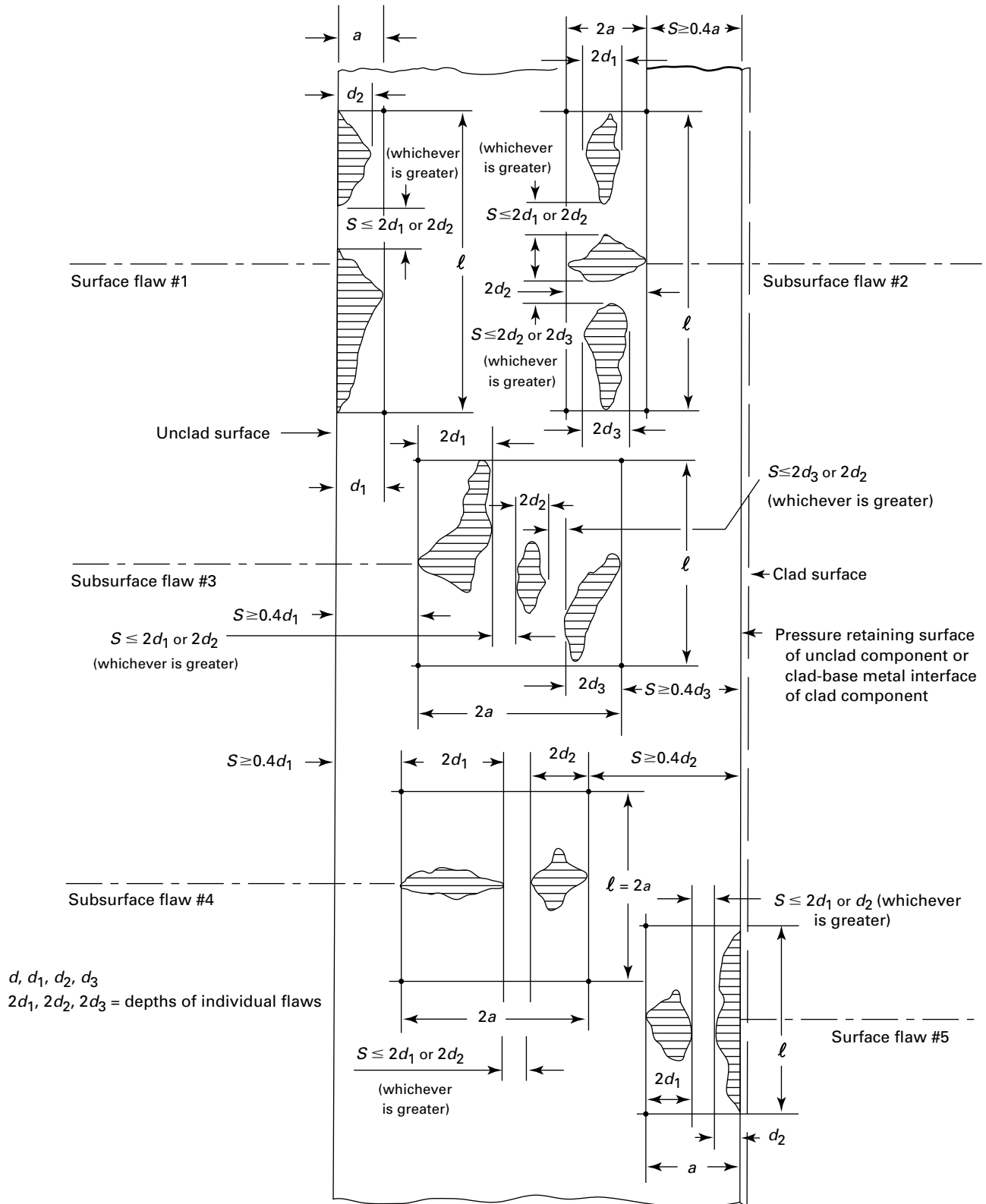


Figure 3
Flaws Oriented Primarily in Parallel Planes

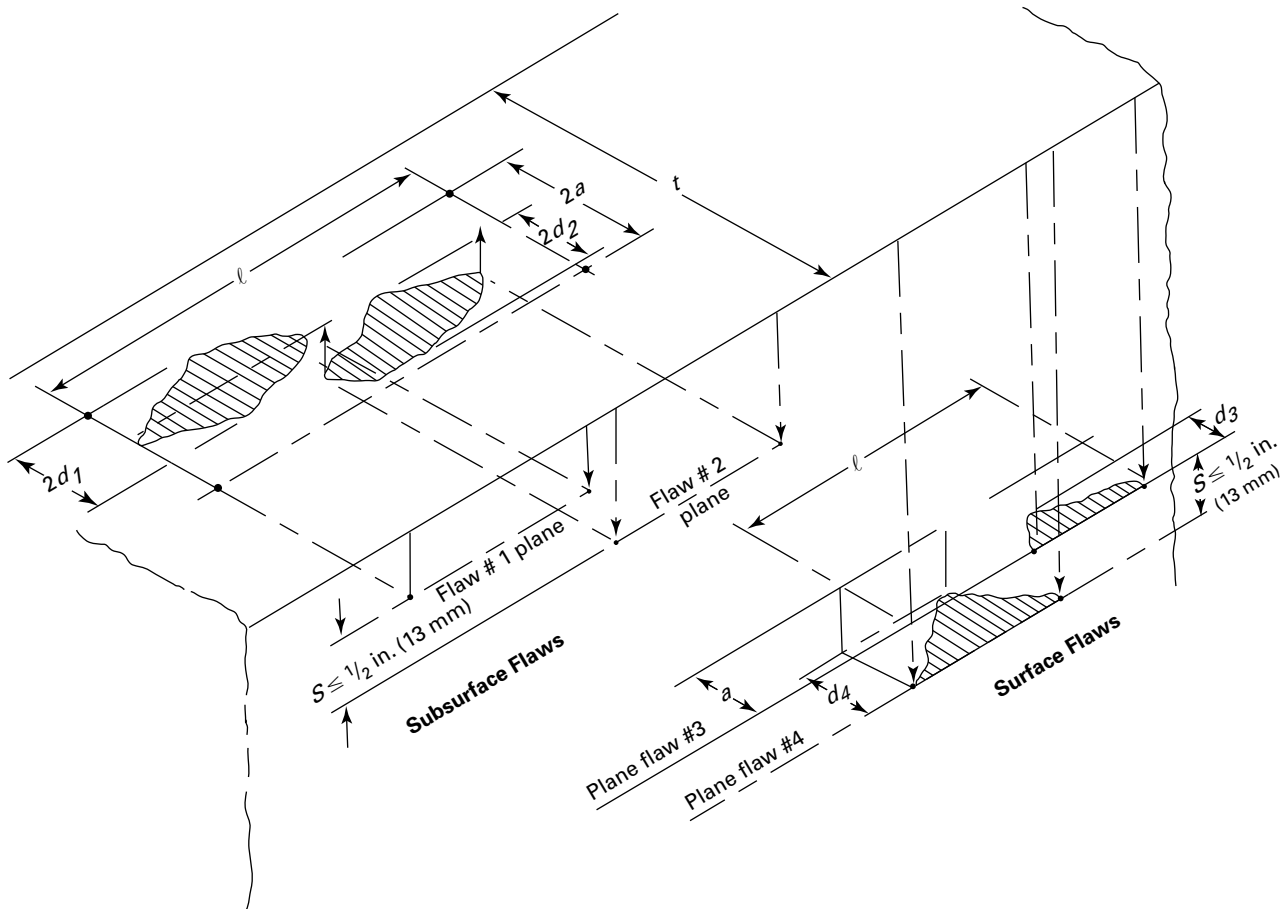


Figure 4
Nonaligned Coplanar Flaws in Plane Normal to Pressure Retaining Surface (Illustrative Flaw Configurations)

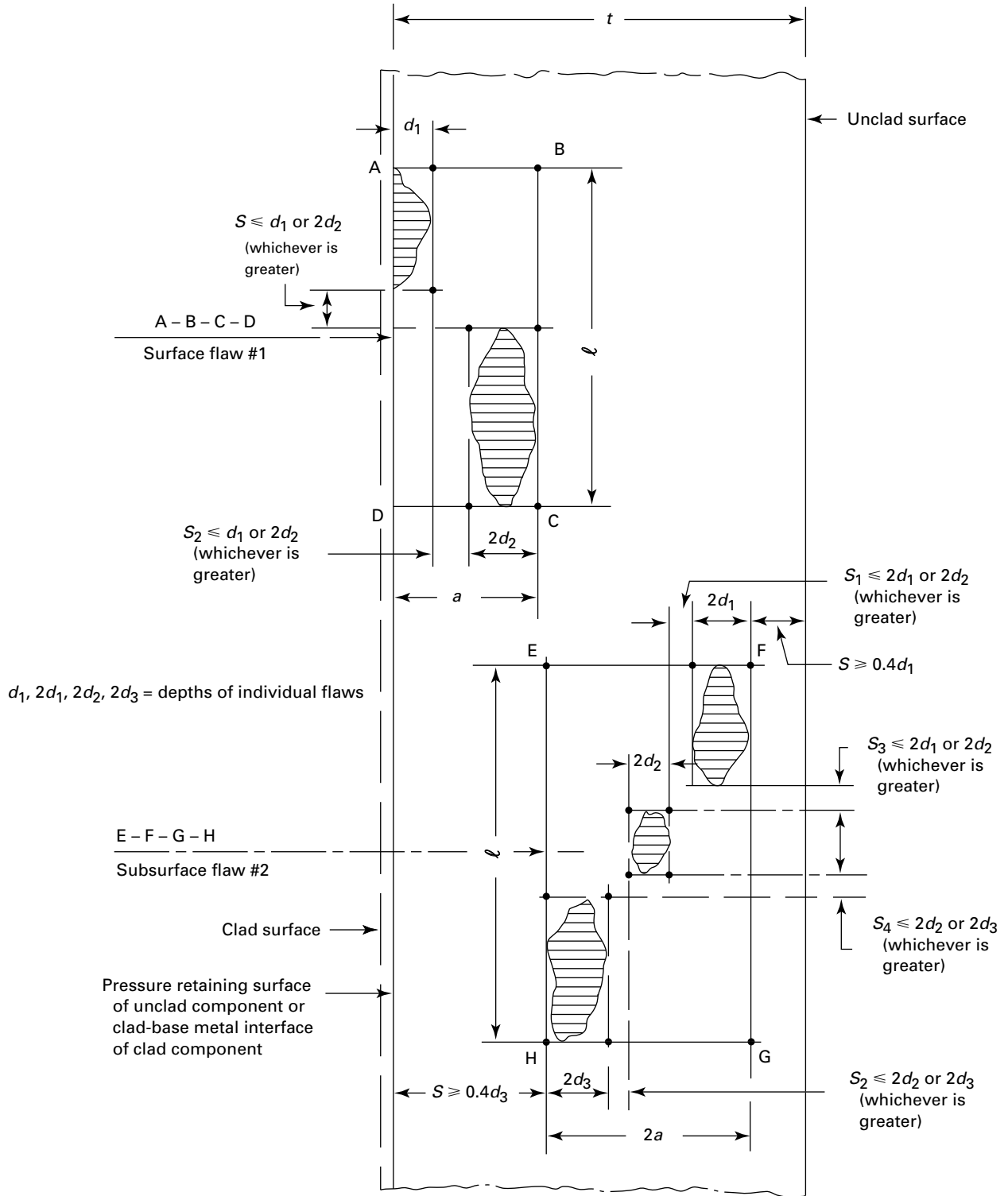
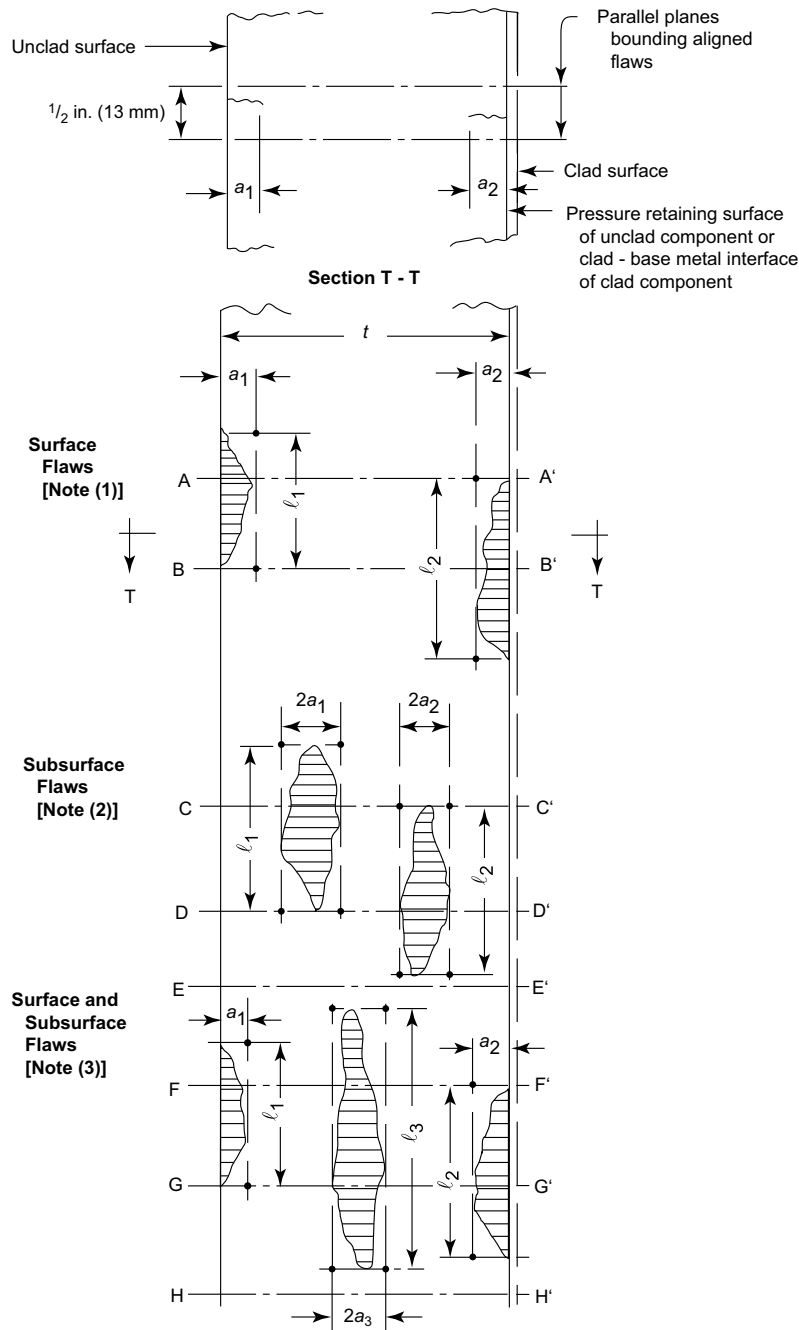


Figure 5
Multiple Aligned Planar Flaws



GENERAL NOTE: In the Notes below, the flaw depth dimensions a_s and a_e are the allowable flaw standards for surface and subsurface flaws, respectively.

NOTES:

- (1) This illustration indicates two surface flaws. The first, a_1 , is on the outer surface of the component, and the second, a_2 , is on the inner surface:
 $(a_1 + a_2) \leq (a_s + a'_s)/2$ within planes A-A' and B-B'
- (2) This illustration indicates two subsurface flaws: $(a_1 + a_2) \leq (a_e + a'_e)/2$ within planes C-C' and D-D'
- (3) This illustration indicates two surface flaws and one subsurface flaw:
 - (a) $(a_1 + a_3) \leq (a_s + a'_e)/2$ within planes E-E' and F-F'
 - (b) $(a_1 + a_2) \leq (a_s + a_e + a'_s)/3$ within planes F-F' and G-G'
 - (c) $(a_2 + a_3) \leq (a'_s + a_e)/2$ within planes G-G' and H-H'

SUPPLEMENT I: EDDY CURRENT SURFACE EXAMINATION PROCEDURE REQUIREMENTS

(a) *Procedure Requirements.* A written procedure shall be provided containing a statement of scope that specifically defines the limits of procedure applicability (e.g., material specification, grade, type, or class). The procedure shall reference a technique specification, delineating the essential variables, qualified in accordance with the requirements below.

(b) *Procedure Specifications*

(1) The eddy current procedure shall specify the following regarding data acquisition:

(-a) instrument or system, including manufacturer's name and model

(-b) size and type of probe, including manufacturer's name and part number

(-c) analog cable type and length

(-d) examination frequencies, or minimum and maximum range, as applicable

(-e) coil excitation mode (e.g., absolute or differential)

(-f) minimum data to be recorded

(-g) method of data recording

(-h) minimum digitizing rate (samples per inch) or maximum scanning speed (for analog systems), as applicable

(-i) scan pattern, when applicable (e.g., helical pitch and direction, rectilinear rotation, length, scan index, or overlap)

(-j) magnetic bias technique, when applicable

(-k) material type

(-l) coating type and thickness, when applicable

(2) The eddy current procedure shall define the following regarding data analysis:

(-a) method of calibration (e.g., phase angle or amplitude adjustments)

(-b) channel and frequencies used for analysis

(-c) extent or area of the component evaluated

(-d) data review requirements (e.g., secondary data review, computer screening)

(-e) reporting requirements (i.e., signal-to-noise threshold, voltage threshold, flaw depth threshold)

(-f) methods of identifying flaw indications and distinguishing them from nonrelevant indications, such as indications from probe lift-off or conductivity and permeability changes in weld material

(-g) manufacturer and model of eddy current data analysis equipment, as applicable

(-h) manufacturer, title, and version of data analysis software, as applicable

(3) The procedure shall address requirements for system calibration. Calibration requirements include those actions required to ensure that the sensitivity and accuracy of the signal amplitude and time outputs

of the examination system, whether displayed, recorded, or automatically processed, are repeatable and correct. Any process of calibrating the system is acceptable; a description of the calibration process shall be included in the procedure.

(4) Data acquisition and analysis procedures may be combined or separate, provided the above requirements are met.

(c) *Personnel Requirements*

(1) Personnel performing data acquisition shall have received specific training and shall be qualified by examination, in accordance with the employer's written practice, in the operation of the equipment, applicable techniques, and recording of examination results.

(2) Personnel performing analysis of data shall have received additional specific training in the data analysis techniques used in the procedure qualification and shall successfully complete the procedure qualification described below.

(3) American Society of Nondestructive Testing (ASNT) standards SNT-TC-1A or CP 189 shall be used as a guideline.

(4) Personnel qualifications may be combined provided all requirements are met.

(d) *Procedure Qualification*

(1) Data sets for detection and sizing shall meet requirements shown below.

(2) The eddy current procedure and equipment shall be considered qualified upon successful completion of the procedure qualification.

(3) *Essential Variables.* An essential variable is a procedure, software, or hardware item that, if changed, could result in erroneous examination results. Further, any item that could decrease the signal-to-noise ratio to less than 2:1 shall be considered an essential variable.

(4) Any two procedures with the same essential variables are considered equivalent. Equipment with essential variables that vary within the demonstrated ranges identified in the Data Acquisition Procedure Specification shall be considered equivalent. When the procedure allows more than one value or range for an essential variable, the qualification test shall be repeated at the minimum and maximum value for each essential variable with all other variables remaining at their nominal values. Changing essential variables may be accomplished during successive procedure qualifications involving different personnel; each data analyst need not demonstrate qualification over the entire range of every essential variable.

(e) *Qualification Requirements*

(1) Specimens to be used in the qualification test shall meet the requirements listed herein unless a set of test specimens is designed to accommodate specific limitations stated in the scope of the examination procedure (e.g., surface roughness or contour limitations). The same specimens may be used to demonstrate both

detection and sizing qualification. For examination of vessels with coated surfaces, Section V, Article 8 shall apply.

(2) Specimens shall be fabricated from the same base material nominal composition (UNS Number) and heat treatment (e.g., solution annealed, precipitation hardened, solution heat treated and aged) as those to be examined.

(3) Specimen surface roughness and contour shall be generally representative of the surface roughness and contour of the component surface to be examined. The examination surface curvature need not be simulated if the ratio of the component diameter to the coil diameter exceeds 20:1.

(4) Welding shall be performed with the same filler material AWS classification and postweld heat treatment (e.g., as welded, solution annealed, stress relieved) as the welds to be examined.

(5) *Defect Conditions*

(-a) The qualification flaws shall be cracks or notches.

(-b) The length of cracks or notches open to the surface shall not exceed 0.125 in. (3.2 mm).

(-c) The maximum depth of a crack or compressed notch shall be 0.040 in. (1.02 mm).

(-d) Machined notches shall have a maximum width of 0.010 in. (0.25 mm) and a maximum depth of 0.020 in. (0.51 mm).

(6) *Demonstration Specimens.* The demonstration specimen shall include one crack or notch at each of the following locations:

(-a) on the weld

(-b) in the heat affected zone

(-c) at the fusion line of the weld

(-d) in the base material

(7) *Procedure Qualification Acceptance Criteria.* All flaws in each of the four identified areas shall be detected with a minimum 2:1 signal-to-noise ratio at the maximum digitization rate (for digital systems) or maximum scanning speed (for analog systems) permitted by the procedure.

(f) *Evaluation of Eddy Current Results.* Eddy current results are evaluated in accordance with the procedure described in para. (b)(2) above. For this Case, ET is used to simply confirm that a UT flaw is in fact, surface connected. If a UT flaw is determined by ET to be surface connected, it shall comply with Acceptance Standards in para. (g) below.

(g) *Acceptance Standards.* These acceptance standards apply unless other more restrictive standards are specified for specific materials or applications within the Construction Code. All surfaces examined shall be free of relevant ET surface flaw indications.

Case 2817

Section VIII, Division 1 Plate-and-Frame Heat Exchanger in Section I Feedwater System

Section I

Approval Date: January 8, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a plate-and-frame heat exchanger constructed under the provisions of Section VIII, Division 1 be installed in a Section I feedwater piping system?

Reply: It is the opinion of the Committee that a plate-and-frame heat exchanger constructed in accordance with the rules of Section VIII, Division 1 may be installed in a Section I boiler, provided the following requirements are met:

(a) The heat exchanger is installed in boiler external piping (BEP) within the certification boundary of the Section I completed boiler unit.

(b) The heat exchanger shall conform to the rules for unfired steam boilers of Section VIII, Division 1, UW-2(c).

(c) The MAWP of the feedwater side of the heat exchanger shall not be less than the design pressure requirements of ASME B31.1, paragraph 122.1.3.

(d) The design temperature of the plates shall not be lower than that permitted by ASME B31.1 for saturated steam. If the heat exchanger is heated with superheated steam, the design temperature of the plates shall not be lower than the saturation temperature permitted by ASME B31.1 plus 35°F (20°C). Gasket material shall be suitable for the design pressure and temperature of the plates.

(e) The materials shall be limited to those permitted by Section VIII, Division 1.

(f) The requirements for postweld heat treatment shall be per Section VIII, Division 1, UW-40. For P-No. 1 materials, the postweld heat treatment exemptions of Table UCS-56-1, General Note (b) may be applied.

(g) The heat exchanger shall be stamped with the ASME Certification Mark with the U Designator and also shall include this Case number in the stamping.

(h) The heat exchanger shall be documented with Form U-1, Manufacturer's Data Report (Section VIII, Division 1) and be referenced in the Section I Master Data Report.

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Case 2820

Composite Pressure Vessels for High Pressure Fluids in Accordance With Mandatory Appendix 8

Section X

Approval Date: November 29, 2014

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions and requirements may oil and gas industry drilling fluids or other general fluids be used as the operating fluid in composite pressure vessels designed and constructed under the rules of Section X, Mandatory Appendix 8 for Class III vessels with nonload-sharing liners?

Reply: It is the opinion of the Committee that Class III composite pressure vessels may be designed and constructed under the rules of Section X, Mandatory Appendix 8 with drilling fluids or other general fluids as the operating fluid, provided the following requirements are met:

(a) Contained fluids shall be compatible with the composite, liner, and nozzle materials. If compatibility is not already demonstrated, testing must be conducted

to confirm compatibility. Confirmation of compatibility shall be reported in the Fabricator's Data Report. Known compatible fluid materials and noncompatible fluid materials shall be listed in the User's Design Specification. Toxic gases shall not be used.

(b) Allowed permeation rates shall be included in the User Design Specification. The fabricator shall confirm permeation rate through testing, as described in Mandatory Appendix 8, 8-700.5.7.

(c) Permeation testing may be conducted with the fluid to be contained, or by using an alternate fluid with adjustment in rate made by considering relative molecular weight, or by using relative viscosity, as appropriate.

(d) Additional pressure and bending loads present due to containment of the fluids shall be considered in the stress analysis, in addition to changes made to the test pressures or procedures as appropriate during qualification testing to accurately assess the maximum design stresses.

(e) This Case number shall be shown on the Fabricator's Data Report.

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Case 2821

Impact Testing of SA-540/SA-540M, Grade B23, Class 3 Bolting

Section VIII, Division 2

Approval Date: February 24, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May bolting conforming to SA-540/SA-540M, Grade B23, Class 3, up to 150 mm (6 in.) diameter, inclusive, be used at an MDMT colder than permitted by Table 3.4 for flanges designed to para. 4.16?

Reply: It is the opinion of the Committee that bolting conforming to SA-540/SA-540M, Grade B23, Class 3, up to 150 mm (6 in.) diameter, inclusive, may be used

at an MDMT colder than permitted by Table 3.4 for flanges designed to Section VIII, Division 2, para. 4.16, provided the following requirements are met:

(a) Impact tests shall be performed in accordance with the procedures in SA-320/SA-320M at the required MDMT. The average for three full-size Charpy V-notch impact specimens shall be at least 41 J (30 ft-lb), with the minimum value for any individual specimen no less than 34 J (25 ft-lb).

(b) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2822-2

Fatigue Evaluation for Class 2 Parts Constructed With SA-182/ SA-182M F91, SA-213/SA-213M T91, SA-335/SA-335M P91, SA-336/SA-336M F91, and SA-387/SA-387M 91 Class 2 at Temperatures Greater Than 371°C (700°F) and Less Than or Equal to 500°C (932°F)

Section VIII, Division 2

Approval Date: December 11, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what requirements may Section VIII, Division 2, Class 2 pressure parts constructed with SA-182/SA-182M F91, SA-213/SA-213M T91, SA-335/SA-335M P91, SA-336/SA-336M F91, and SA-387/SA-387M 91 Class 2 for operating temperatures greater than 371°C (700°F) and less than or equal to 500°C (932°F) be evaluated for fatigue?

Reply: It is the opinion of the Committee that Section VIII, Division 2, Class 2 pressure parts constructed with SA-182/SA-182M F91, SA-213/SA-213M T91, SA-335/SA-335M P91, SA-336/SA-336M F91, and SA-387/SA-387M 91 Class 2 for operating temperatures greater than 371°C (700°F) and less than or equal to 500°C (932°F) may be evaluated for fatigue, provided the following requirements are satisfied.

(a) The time, temperature, and load history shall be provided in the User's Design Specification. The load history shall include both design and operating conditions. The design conditions shall be used for analyses defined in (b) and (c). The operating conditions are used for analyses defined in (d) and (e). The maximum permissible temperature for the analyses defined in (d) and (e) is 500°C (932°F).

(b) The design of pressure parts or nonpressure parts, i.e., skirt and skirt attachment, may be in accordance with the design-by-rule requirements of Part 4 or the design-by-analysis requirements of Part 5. In either case, the allowable stress, S , to be used for design shall be in accordance with Table 5A of ASME Section II, Part D. If design-by-analysis is used to qualify the design of a pressure part or nonpressure part, the design-by-analysis shall be based on the elastic stress analysis methods in Part 5.

(c) Restrictions on the design of pressure parts shall be as follows:

(1) The diameter ratio of the shell shall satisfy $D_o/D_i \leq 1.2$.

(2) Standard pressure parts that comply with an ASME product listed in Part 1, Table 1.1, and para. 4.1.11 may be used for closure components or piping connections at the pressure-temperature rating listed in the ASME standard.

(3) The skirt attachment detail shall be in accordance with para. 4.2, Fig. 4.2.4, illustration (e). Figure 4.2.4, illustration (f) may be used if the requirements of (d)(5) are satisfied.

(4) Integral reinforcement shall be used for nozzles and conical transitions.

(5) Flange designed in accordance with Part 4, para. 4.16 may be used for closure components or piping connections, except that the allowable stress, S , shall be in accordance with Table 1A of Section II, Part D.

(6) The rules for external pressure and compressive stress design in Part 4, para. 4.4 may be used if the strain rate computed using eq. (d)(3)(3) based on the membrane stress for the most severe combination of applied loads that results in compressive stress satisfy eq. (1)

$$\dot{\epsilon} \leq \frac{3(10)^{-8}}{\text{hr}} \quad (1)$$

(d) An inelastic analysis including the effect of creep shall be performed for pressure parts based on the following requirements. This analysis is not required for standard pressure parts and bolted flanges specified in (c)(2) and (c)(5).

(1) The inelastic analysis shall be based on the histogram defined in (-a) using one of the following options. Either option may be used for different components in the vessel.

(-a) *Option 1.* An approximate ratcheting analysis may be performed, based on establishing elastic shakedown at all points in the structure. If this option is chosen, a conservative load histogram shall be used based on the most extreme conditions of stress and temperature. A minimum of two complete cycles shall be computed, including a hold time of a minimum of one year, for the purpose of establishing the effects of creep relaxation. During the last computed cycle, a state of linear elasticity must be demonstrated throughout the cycle. If this criterion is not achieved, a full inelastic analysis using the actual time-dependent thermal and mechanical loading histograms shall be performed as per Option 2.

(-b) *Option 2.* If it is elected not to perform a simplified analysis as per Option 1, or if such an analysis is carried out and fails to demonstrate elastic shakedown according to the criterion stated in Option 1, then a full inelastic analysis shall be performed using the actual time-dependent thermal and mechanical loading histograms, including all operating cycles and their associated hold times. This analysis shall be continued for all cycles defined in the load histogram including their associated hold times, or until the analysis demonstrates shakedown to a stable state or a steady ratchet deformation. In either case, the strain limits in (6)(-a) shall be satisfied.

Protection against ratcheting may be demonstrated using an elastic analysis in lieu of inelastic analysis. To evaluate protection against ratcheting, the following limit shall be satisfied:

$$P_L + P_b + Q + F \leq (S_h + S_{yc}) \quad (2)$$

(2) Elastic, perfectly plastic stress-strain curves based on the yield strengths consistent with the operating temperature envelope, and the following creep rate shall be used in the analysis.

(3) The strain rate to be used in the inelastic analysis (i.e., creep model) shall be determined using eqs. (3) through (14). The coefficients for these equations are provided in Tables 1 and 1M.

$$\dot{\epsilon}_c = \frac{\dot{\epsilon}_{oc}}{1 - D_c} \quad (3)$$

$$\log_{10} \dot{\epsilon}_{oc} = - \left\{ A_0 + \left(\frac{A_1 + A_2 S_l + A_3 S_l^2 + A_4 S_l^3}{T} \right) \right\} \quad (4)$$

$$S_l = \log_{10}(\sigma_e) \quad (5)$$

$$\sigma_e = \frac{1}{\sqrt{2}} \left[(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2 \right]^{0.5} \quad (6)$$

$$D_c = \int_0^t \dot{D}_c dt \leq 1.0 \quad (7)$$

$$\dot{D}_c = \Omega_m \dot{\epsilon}_{oc} \quad (8)$$

$$\Omega_m = \Omega_n^{\delta+1} \quad (9)$$

$$\Omega_n = \max. [(\Omega - n), 3.0] \quad (10)$$

$$\log_{10} \Omega = B_0 + \left(\frac{B_1 + B_2 S_l + B_3 S_l^2 + B_4 S_l^3}{T} \right) \quad (11)$$

$$n = - \left(\frac{A_2 + 2A_3 S_l + 3A_4 S_l^2}{T} \right) \quad (12)$$

$$\delta = \beta \left(\frac{3p}{\sigma_e} - 1.0 \right) \quad (13)$$

$$p = \frac{\sigma_1 + \sigma_2 + \sigma_3}{3} \quad (14)$$

(4) The inelastic analysis shall be performed for selected locations experiencing the most extreme conditions of stress and temperature to determine the creep life absent fatigue, L_{caf} . Sufficient locations shall be selected to ensure that the most critical conditions have been considered. The creep life absent fatigue is defined as the time in which the inelastic analysis produces an accumulated creep damage such that $0.95 \leq D_c < 1.0$ or 1,000,000 hours, whichever is reached first. A range is given for D_c to account for numerical accuracy in the inelastic analysis. For design purposes and to account for uncertainties in the analysis, a lower value of D_c may be used, at the discretion of the designer, to establish a conservative value for L_{caf} .

(5) The creep damage at all locations shall be such that $D_c < 1.0$. In addition, the weldment and adjacent base material of all weld joints shall be located a minimum distance of 25 mm (1 in.), measured from the weld bevel, from regions where the creep damage, D_c , exceeds 0.50.

(6) Based on the results of the inelastic analysis, the following criteria shall be satisfied:

(-a) The equivalent total accumulated inelastic strain shall not exceed the values in Table 2.

(-b) If the design of the component is based on Part 5, see para. (b), then the protection against local failure shall be determined in accordance with Part 5, para. 5.3.3. This analysis shall not consider the effects of creep.

(e) The permissible number of cycles, N , and the creep life with fatigue, L_{cwf} , at each point in the component shall be determined in accordance with one of the following methods. The permissible number of cycles and the creep life with fatigue shall satisfy the specified design requirements in the User's Design Specification.

(1) If Option 1 is used in (d)(1), the fatigue screening analysis in accordance with Part 5, para. 5.5.2.4 may be used except that the fatigue curves in Figures 1 and 1M and Tables 3 and 3M shall be used in the screening assessment, and the value of S_{as} shall be based on $(10)^4$ cycles. In addition, in Steps 3 and 4 of para. 5.5.2.4, the alternating equivalent stress amplitude based on the primary plus secondary plus peak stress determined from shakedown analysis in (d)(1) may be used instead of C_1S . The permissible number of cycles, N , in eq. (15) is determined in Step 3 of para. 5.5.2.4. The creep life with fatigue, L_{cwf} , is determined using eq. (15) or (16), as applicable. The equivalent plastic strain amplitude, $\Delta\varepsilon_{peq}$, in eqs. (15) and (16) may be determined from Table 4 as a function of the alternating equivalent stress amplitude.

$$L_{cwf} = L_{caf} \cdot \left(\frac{\beta_{cf} \cdot \Delta\varepsilon_{peq} \cdot N}{\exp[\beta_{cf} \cdot \Delta\varepsilon_{peq} \cdot N] - 1} \right), \quad \Delta\varepsilon_{peq} > 0 \quad (15)$$

$$L_{cwf} = L_{caf}, \quad \Delta\varepsilon_{peq} = 0 \quad (16)$$

(2) If Option 2 is used in (d)(1), then the fatigue analysis shall be performed in accordance with Part 5, para. 5.5.4, except that the fatigue curves in Figures 1 and 1M and Tables 3 and 3M shall be used to determine the accumulated fatigue damage. The accumulated fatigue damage shall satisfy the requirements of Part 5, para. 5.5.4. The creep life with fatigue, L_{cwf} , is determined using eq. (1)(15) or (1)(16), as applicable. The equivalent plastic strain range for the k^{th} loading condition or cycle in eqs. (17) and (18) is determined directly from the strain-based fatigue analysis results.

$$L_{cwf} = L_{caf} \cdot \left(\frac{\beta_{cf} \cdot \sum_{i=1}^k \Delta\varepsilon_{peq,k}}{\exp\left[\beta_{cf} \cdot \sum_{i=1}^k \Delta\varepsilon_{peq,k}\right] - 1} \right), \quad \Delta\varepsilon_{peq} > 0 \quad (17)$$

$$L_{cwf} = L_{caf}, \quad \Delta\varepsilon_{peq} = 0 \quad (18)$$

(f) Nondestructive examination of all welds shall be performed in accordance with Examination Group 1a, see Part 7, Tables 7.1 and 7.2. The supplemental examination for cyclic service in para. 7.4.7 shall be performed.

(g) This Case number shall be marked on the nameplate and shown in the Manufacturer's Data Report.

(h) *Nomenclature*

$A_0 \dots A_4$ = material coefficients for the MPC Project Omega strain-rate-parameter, see Tables 1 and 1M

$B_0 \dots B_4$ = material coefficients for the MPC Project Omega Omega-parameter, see Tables 1 and 1M

β = MPC Project Omega parameter equal to $\frac{1}{3}$

β_{cf} = creep fatigue damage factor equal to 2.0

D_c = creep damage

\dot{D}_c = creep damage rate

$\Delta\varepsilon_{peq}$ = equivalent plastic strain amplitude based on the alternating equivalent stress amplitude determined in the fatigue screening analysis

$\Delta\varepsilon_{peq,k}$ = equivalent plastic strain amplitude for the k^{th} loading condition or cycle

δ = MPC Project Omega parameter

$\dot{\varepsilon}_c$ = creep strain rate

$\dot{\varepsilon}_{co}$ = initial creep strain rate at the start of the time period being evaluated based on the stress state and temperature

F = additional stress produced by the stress concentration over and above the nominal stress

L_{caf} = creep life absent fatigue

L_{cwf} = creep life with fatigue

n = MPC Project Omega parameter

N = permissible number of cycles

p = hydrostatic stress

P_b = primary bending equivalent stress

P_L = local primary membrane equivalent stress

Q = secondary equivalent stress resulting from operating loadings

σ_e = effective stress

σ_1 = principal stress in the 1-direction

σ_2 = principal stress in the 2-direction

σ_3 = principal stress in the 3-direction

S_h = allowable stress at the maximum temperature for the cycle under consideration

S_{yc} = yield strength at the minimum temperature for the cycle under consideration

t = time, hr

T = temperature

Ω = uniaxial Omega damage parameter

Ω_m = multiaxial Omega damage parameter

Ω_n = adjusted uniaxial Omega damage parameter

Table 1
MPC Project Omega Creep Data

Material	Strain Rate Parameter, $\dot{\epsilon}_0$ [Note (1)]		Omega Parameter, Ω [Note (1)]	
9Cr-1Mo-V	A_0	-34	B_0	-2.00
	A_1	73,201.8	B_1	7,200.0
	A_2	-2,709.0	B_2	-1,500.0
	A_3	-4,673.0	B_3	0
	A_4	-569	B_4	0

GENERAL NOTE: The coefficients in this table represent minimum material behavior.

NOTE: (1) The units of measure for computing the strain rate parameter, $\dot{\epsilon}_0$, and the Omega parameter, Ω , using the coefficients in this table are ksi and °R.

Table 1M
MPC Project Omega Creep Data

Material	Strain Rate Parameter, $\dot{\epsilon}_0$ [Note (1)]		Omega Parameter, Ω [Note (1)]	
9Cr-1Mo-V	A_0	-34	B_0	-2
	A_1	40290.39	B_1	4698.864
	A_2	2182.414	B_2	-833.333
	A_3	-1800.8	B_3	0
	A_4	-316.111	B_4	0

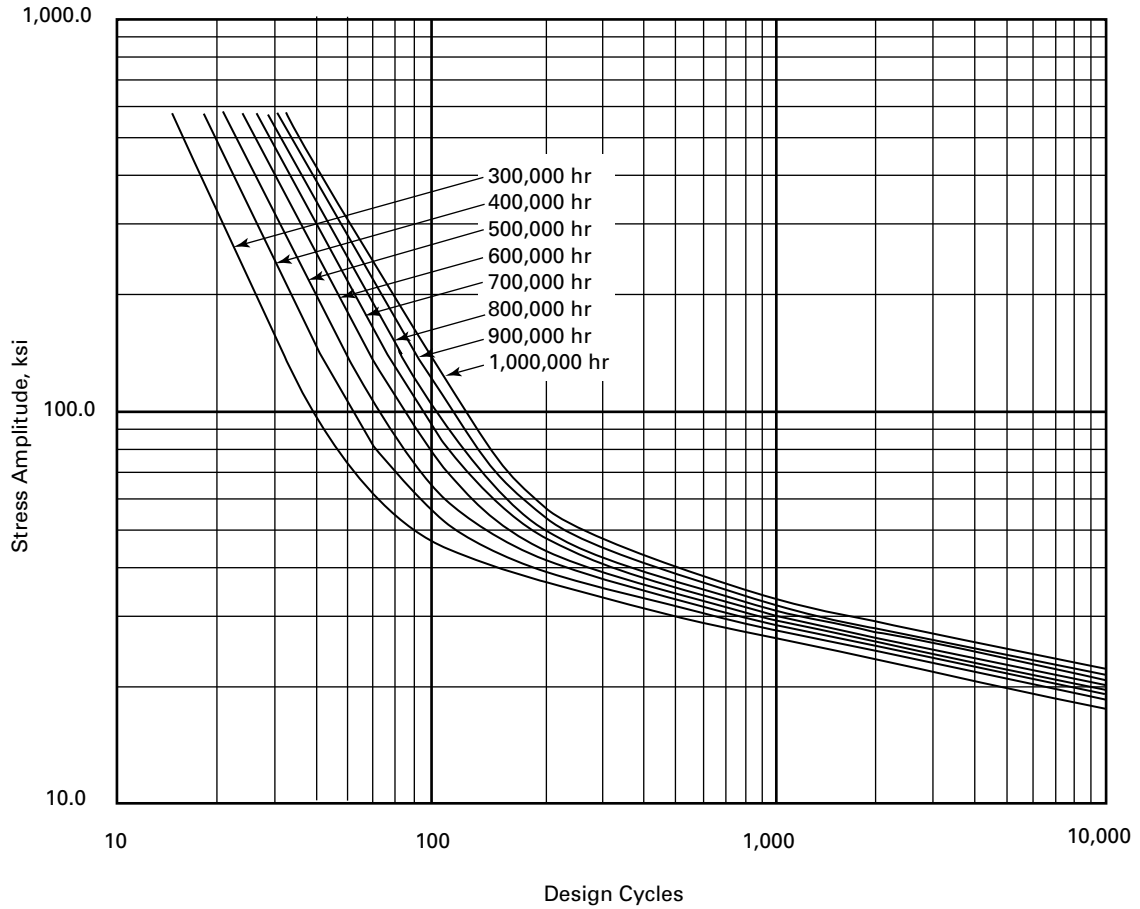
GENERAL NOTE: The coefficients in this table represent minimum material behavior.

NOTE: (1) The units of measure for computing the strain rate parameter, $\dot{\epsilon}_0$, and the Omega parameter, Ω , using the coefficients in this table are MPa and °K.

Table 2
Total Accumulated Inelastic Strain

Type of Stress	Equivalent Total Accumulated Inelastic Strain	
	Weld and HAZ	Other Parts
Membrane	0.5%	1.0%
Membrane plus bending	1.25%	2.5%
Local (at any point)	2.5%	5.0%

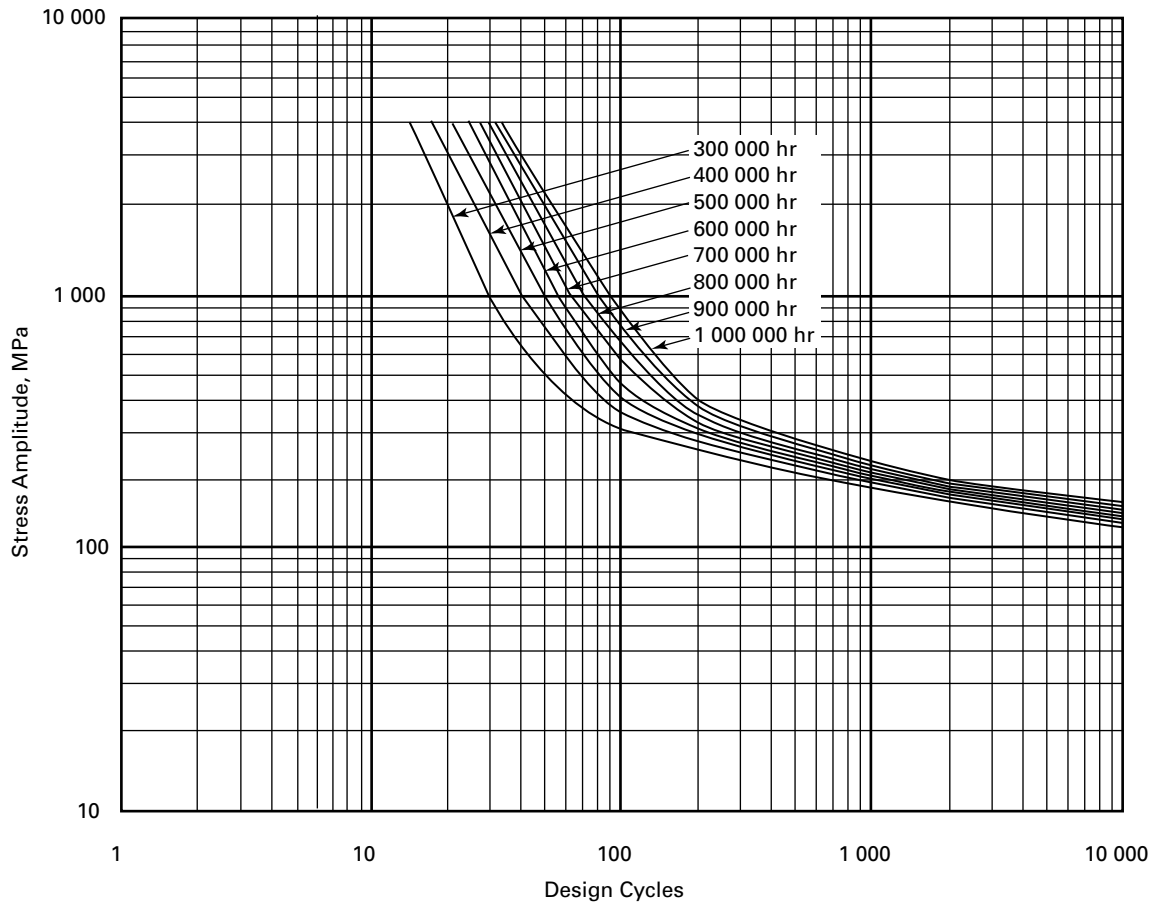
Figure 1
Design Fatigue Curve for 9Cr-1Mo-V Steel for Temperatures Not Exceeding 932°F, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue



GENERAL NOTES:

- (a) Interpolation of design cycles as a function of design life is permitted.
- (b) Extrapolation of design cycles as a function of stress amplitude is not permitted.
- (c) The reference temperature and Young's Modulus for these fatigue curves are 932°F and 26,106 ksi, respectively.

Figure 1M
Design Fatigue Curve for 9Cr-1Mo-V Steel for Temperatures Not Exceeding 500°C, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue



GENERAL NOTES:

- (a) Interpolation of design cycles as a function of design life is permitted.
- (b) Extrapolation of design cycles as a function of stress amplitude is not permitted.
- (c) The reference temperature and Young's Modulus for these fatigue curves are 500°C and 180,000 MPa, respectively.

Table 3
Design Fatigue Curve for 9Cr-1Mo-V Steel for Temperatures Not Exceeding 932°F, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue

Stress Amplitude, ksi	Creep Life Absent Fatigue, hr							
	300,000	400,000	500,000	600,000	700,000	800,000	900,000	1,000,000
577.3	15	18	21	24	26	29	31	32
440.6	17	21	25	28	31	34	37	39
339.2	20	25	29	33	37	40	44	47
263.9	22	28	34	39	43	48	52	56
207.9	26	33	39	45	51	56	61	66
166.2	29	37	45	52	59	65	71	77
135.2	33	42	51	60	68	75	83	89
112.0	37	48	58	68	78	87	95	104
94.6	41	54	66	77	88	99	109	119
81.5	46	61	74	88	100	113	125	136
71.6	52	68	84	99	114	128	142	155
64.1	58	76	94	111	128	145	161	176
58.3	64	85	105	125	144	163	181	199
53.9	72	95	117	139	161	183	204	224
50.3	80	105	131	156	180	205	228	252
47.6	88	117	145	174	201	229	256	282
45.3	98	130	162	193	224	255	285	315
43.4	109	144	180	215	249	284	318	352
41.9	121	160	199	238	277	316	354	392
40.6	133	177	221	265	308	351	394	436
39.4	148	197	245	294	342	390	437	485
38.4	164	218	272	325	379	432	485	538
37.4	181	241	301	360	420	479	538	597
36.6	200	267	333	399	465	531	596	662
35.8	222	295	369	442	515	588	661	734
35.0	245	327	408	489	570	651	732	813
34.3	271	361	451	541	631	721	810	900
33.6	300	400	499	599	698	798	897	996
33.0	332	442	553	663	773	883	993	1,102
32.3	367	489	611	733	855	977	1,098	1,220
31.7	406	541	676	811	946	1,080	1,215	1,350
31.1	449	598	747	897	1,046	1,195	1,344	1,493
30.5	496	661	827	992	1,157	1,322	1,487	1,651
30.0	549	731	914	1,097	1,279	1,462	1,644	1,826
29.4	607	809	1,011	1,213	1,415	1,616	1,818	2,020
28.9	671	894	1,118	1,341	1,564	1,787	2,011	2,234
28.3	742	989	1,236	1,483	1,730	1,976	2,223	2,470
27.8	820	1,093	1,366	1,639	1,912	2,185	2,458	2,731
27.3	906	1,209	1,511	1,813	2,115	2,416	2,718	3,020
26.8	1,002	1,336	1,670	2,004	2,338	2,672	3,006	3,339
26.3	1,108	1,477	1,847	2,216	2,585	2,954	3,323	3,692
25.8	1,225	1,633	2,042	2,450	2,858	3,266	3,674	4,082
25.3	1,354	1,806	2,257	2,709	3,160	3,611	4,063	4,514
24.8	1,497	1,997	2,496	2,995	3,494	3,993	4,492	4,991
24.4	1,656	2,207	2,759	3,311	3,863	4,414	4,966	5,518
23.9	1,830	2,440	3,050	3,661	4,271	4,881	5,491	6,100

Table 3
Design Fatigue Curve for 9Cr-1Mo-V Steel for Temperatures Not Exceeding 932°F, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue (Cont'd)

Stress Amplitude, ksi	Creep Life Absent Fatigue, hr							
	300,000	400,000	500,000	600,000	700,000	800,000	900,000	1,000,000
23.5	2,024	2,698	3,373	4,047	4,722	5,396	6,070	6,745
23.1	2,237	2,983	3,729	4,474	5,220	5,966	6,711	7,457
22.6	2,473	3,298	4,122	4,947	5,771	6,596	7,420	8,244
22.2	2,735	3,646	4,558	5,469	6,381	7,292	8,204	9,115
21.8	3,023	4,031	5,039	6,047	7,054	8,062	9,070	10,078
21.4	3,343	4,457	5,571	6,685	7,799	8,913	10,028	11,142
21.0	3,696	4,927	6,159	7,391	8,623	9,855	11,086	12,318
20.6	4,086	5,448	6,809	8,171	9,533	10,895	12,257	13,619
20.2	4,517	6,023	7,528	9,034	10,540	12,045	13,551	15,057
19.9	4,994	6,659	8,323	9,988	11,652	13,317	14,982	16,646
19.5	5,521	7,362	9,202	11,042	12,883	14,723	16,564	18,404
19.1	6,104	8,139	10,174	12,208	14,243	16,278	18,312	20,347
18.8	6,749	8,998	11,248	13,497	15,747	17,996	20,246	22,495
18.4	7,461	9,948	12,435	14,922	17,409	19,896	22,383	24,870
18.1	8,249	10,998	13,748	16,498	19,247	21,997	24,747	27,496
17.8	9,120	12,160	15,200	18,240	21,279	24,319	27,359	30,399
17.4	10,083	13,443	16,804	20,165	23,526	26,887	30,248	33,609
17.1	11,147	14,863	18,579	22,294	26,010	29,726	33,441	37,157
16.8	12,324	16,432	20,540	24,648	28,756	32,864	36,972	41,080
16.5	13,625	18,167	22,709	27,250	31,792	36,334	40,875	45,417
16.2	15,064	20,085	25,106	30,127	35,149	40,170	45,191	50,212
15.9	16,654	22,205	27,757	33,308	38,860	44,411	49,962	55,514
15.6	18,412	24,550	30,687	36,825	42,962	49,100	55,237	61,375
15.3	20,356	27,142	33,927	40,713	47,498	54,284	61,069	67,854

GENERAL NOTES:

- (a) Interpolation of design cycles as a function of design life is permitted.
(b) Extrapolation of design cycles as a function of stress amplitude is not permitted.
(c) The reference temperature and Young's Modulus for these fatigue curves are 932°F and 26,106 ksi, respectively.

Table 3M
Design Fatigue Curve for 9Cr-1Mo-V Steel for Temperatures Not Exceeding 500°C, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue

Stress Amplitude, MPa	Creep Life Absent Fatigue, h							
	300 000	400 000	500 000	600 000	700 000	800 000	900 000	1 000 000
3 982	15	18	21	24	26	29	31	32
3 039	17	21	25	28	31	34	37	39
2 339	20	25	29	33	37	40	44	47
1 820	22	28	34	39	43	48	52	56
1 434	26	33	39	45	51	56	61	66
1 147	29	37	45	52	59	65	71	77
932	33	42	51	60	68	75	83	89
772	37	48	58	68	78	87	95	104
652	41	54	66	77	88	99	109	119
562	46	61	74	88	100	113	125	136
494	52	68	84	99	114	128	142	155
442	58	76	94	111	128	145	161	176
402	64	85	105	125	144	163	181	199
371	72	95	117	139	161	183	204	224
347	80	105	131	156	180	205	228	252
328	88	117	145	174	201	229	256	282
312	98	130	162	193	224	255	285	315
300	109	144	180	215	249	284	318	352
289	121	160	199	238	277	316	354	392
280	133	177	221	265	308	351	394	436
272	148	197	245	294	342	390	437	485
265	164	218	272	325	379	432	485	538
258	181	241	301	360	420	479	538	597
252	200	267	333	399	465	531	596	662
247	222	295	369	442	515	588	661	734
242	245	327	408	489	570	651	732	813
237	271	361	451	541	631	721	810	900
232	300	400	499	599	698	798	897	996
227	332	442	553	663	773	883	993	1 102
223	367	489	611	733	855	977	1 098	1 220
219	406	541	676	811	946	1 080	1 215	1 350
215	449	598	747	897	1 046	1 195	1 344	1 493
211	496	661	827	992	1 157	1 322	1 487	1 651
207	549	731	914	1 097	1 279	1 462	1 644	1 826
203	607	809	1 011	1 213	1 415	1 616	1 818	2 020
199	671	894	1 118	1 341	1 564	1 787	2 011	2 234
195	742	989	1 236	1 483	1 730	1 976	2 223	2 470
192	820	1 093	1 366	1 639	1 912	2 185	2 458	2 731
188	906	1 209	1 511	1 813	2 115	2 416	2 718	3 020
185	1 002	1 336	1 670	2 004	2 338	2 672	3 006	3 339
181	1 108	1 477	1 847	2 216	2 585	2 954	3 323	3 692
178	1 225	1 633	2 042	2 450	2 858	3 266	3 674	4 082
175	1 354	1 806	2 257	2 709	3 160	3 611	4 063	4 514
171	1 497	1 997	2 496	2 995	3 494	3 993	4 492	4 991
168	1 656	2 207	2 759	3 311	3 863	4 414	4 966	5 518
165	1 830	2 440	3 050	3 661	4 271	4 881	5 491	6 100

Table 3M
Design Fatigue Curve for 9Cr-1Mo-V Steel for Temperatures Not Exceeding 500°C, Design Cycles as a Function of Stress Amplitude and Creep Life Absent Fatigue (Cont'd)

Stress Amplitude, MPa	Creep Life Absent Fatigue, h							
	300 000	400 000	500 000	600 000	700 000	800 000	900 000	1 000 000
162	2024	2698	3373	4047	4722	5396	6070	6745
159	2237	2983	3729	4474	5220	5966	6711	7457
156	2473	3298	4122	4947	5771	6596	7420	8244
153	2735	3646	4558	5469	6381	7292	8204	9115
150	3023	4031	5039	6047	7054	8062	9070	10078
148	3343	4457	5571	6685	7799	8913	10028	11142
145	3696	4927	6159	7391	8623	9855	11086	12318
142	4086	5448	6809	8171	9533	10895	12257	13619
140	4517	6023	7528	9034	10540	12045	13551	15057
137	4994	6659	8323	9988	11652	13317	14982	16646
135	5521	7362	9202	11042	12883	14723	16564	18404
132	6104	8139	10174	12208	14243	16278	18312	20347
130	6749	8998	11248	13497	15747	17996	20246	22495
127	7461	9948	12435	14922	17409	19896	22383	24870
125	8249	10998	13748	16498	19247	21997	24747	27496
123	9120	12160	15200	18240	21279	24319	27359	30399
120	10083	13443	16804	20165	23526	26887	30248	33609
118	11147	14863	18579	22294	26010	29726	33441	37157
116	12324	16432	20540	24648	28756	32864	36972	41080
114	13625	18167	22709	27250	31792	36334	40875	45417
112	15064	20085	25106	30127	35149	40170	45191	50212
110	16654	22205	27757	33308	38860	44411	49962	55514
108	18412	24550	30687	36825	42962	49100	55237	61375
106	20356	27142	33927	40713	47498	54284	61069	67854

GENERAL NOTES:

- (a) Interpolation of design cycles as a function of design life is permitted.
(b) Extrapolation of design cycles as a function of stress amplitude is not permitted.
(c) The reference temperature and Young's Modulus for these fatigue curves are 500°C and 180 000 MPa, respectively.

Table 4
Stress Amplitude Versus Plastic Strain

Alternating Equivalent Stress Amplitude		Equivalent Plastic Strain Amplitude
ksi	MPa	
577.5	3982	0.02000000
440.7	3039	0.01480000
339.2	2339	0.01095200
263.9	1820	0.00810400
207.9	1434	0.00599700
166.3	1147	0.00443800
135.2	932	0.00328400
112.0	772	0.00243000
94.6	652	0.00179800
81.5	562	0.00133100
71.7	494	0.00098500
64.1	442	0.00072900
58.3	402	0.00053900
53.9	371	0.00039900
50.4	347	0.00029500
47.6	328	0.00021900
45.3	312	0.00016200
43.5	300	0.00012000
41.9	289	0.00008860
40.6	280	0.00006550
39.4	272	0.00004850
38.4	265	0.00003590
37.4	258	0.00002660
36.6	252	0.00001960
35.8	247	0.00001450
35.0	242	0.00001080
34.3	237	0.00000796
33.6	232	0.00000589
33.0	227	0.00000436
32.3	223	0.00000323
31.7	219	0.00000239
31.1	215	0.00000177
30.5	211	0.00000131
30.0	207	0.00000097

GENERAL NOTES:

- (a) The plastic strain below 207 MPa (30 ksi) shall be taken as 0.0.
- (b) Interpolation of data values is permitted.
- (c) Extrapolation of data values is not permitted.

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Case 2823-1

Use of UNS S32003 Ferritic/Austenitic Stainless Steel Plate, Pipe, and Tube for Boilers

Section IV

Approval Date: December 18, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S32003 ferritic/austenitic stainless steel in SA-240/SA-240M plate, SA-790 pipe, and SA-789 tube specifications be used in the construction of Section IV boilers?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the construction of Section IV boilers, provided the following requirements are met:

(a) The material shall be furnished in the heat-treated condition with the heat treatment as listed in the specification.

(b) The allowable stresses for plate, seamless pipe, and seamless tube furnished in accordance with SA-240/SA-240M, SA-789, and SA-790 shall be as listed in [Tables 1, 1M, 2, and 2M](#).

(c) The allowable stresses for welded pipe and tube furnished in accordance with SA-789 and SA-790 shall be as listed in [Tables 3, 3M, 4, and 4M](#).

(d) Welding procedures and performance qualifications shall be conducted in accordance with Section IX.

(e) This material may utilize the minimum thickness exceptions of HF-301.1(c) at pressures up to 160 psi (1100 kPa).

(f) Tubing may utilize the thickness requirements of HF-204.3.

(g) All other requirements of Section IV shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

NOTE: This steel may be expected to develop embrittlement after service at moderately elevated temperatures; see Section II, Part D, Nonmandatory Appendix A.

Table 1
Maximum Allowable Stress Values: SA-789 Seamless Tube, 100 ksi Tensile Strength and 70 ksi Yield Strength

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, ksi
100	20.0
200	19.4
300	18.2
400	18.1
500	18.1

Table 1M
Maximum Allowable Stress Values: SA-789 Seamless Tube, 690 MPa Tensile Strength and 485 MPa Yield Strength

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, MPa
40	138
65	138
100	132
125	128
150	126
200	124
250	124
275	124 [Note (1)]

NOTE: (1) The maximum use temperature shall be 260°C. The value at 275°C is provided for interpolation purposes.

Table 2
Maximum Allowable Stress Values: SA-240/SA-240M Plate and SA-790 Seamless Tube, 90 ksi Tensile Strength and 65 ksi Yield Strength

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, ksi
100	18.0
200	17.5
300	16.4
400	16.3
500	16.3

Table 2M
Maximum Allowable Stress Values: SA-240/SA-240M Plate and SA-790 Seamless Tube, 620 MPa Tensile Strength and 450 MPa Yield Strength

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, MPa
40	124
65	124
100	119
125	116
150	113
200	112
250	112
275	112 [Note (1)]

NOTE: (1) The maximum use temperature shall be 260°C. The value at 275°C is provided for interpolation purposes.

Table 3
Maximum Allowable Stress Values: SA-789 Welded Tube, 100 ksi Tensile Strength and 70 ksi Yield Strength

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, ksi [Note (1)]
100	17.0
200	16.5
300	15.5
400	15.3
500	15.3

NOTE: (1) For welded pipe and tube, the allowable stress values have been multiplied by a factor of 0.85.

Table 3M
Maximum Allowable Stress Values: SA-789 Welded Tube, 690 MPa Tensile Strength and 485 MPa Yield Strength

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, MPa [Note (1)]
40	117
65	117
100	113
125	109
150	107
200	106
250	106
275	106 [Note (2)]

NOTES:

- (1) For welded pipe and tube, the allowable stress values have been multiplied by a factor of 0.85.
- (2) The maximum use temperature shall be 260°C. The value at 275°C is provided for interpolation purposes.

Table 4
Maximum Allowable Stress Values: SA-790 Welded Pipe, 90 ksi Tensile Strength and 65 ksi Yield Strength

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, ksi [Note (1)]
100	15.3
200	14.8
300	14.0
400	13.8
500	13.8

NOTE: (1) For welded pipe and tube, the allowable stress values have been multiplied by a factor of 0.85.

Table 4M
Maximum Allowable Stress Values: SA-789 Welded Tube, 690 MPa Tensile Strength and 485 MPa Yield Strength

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, MPa [Note (1)]
40	106
65	106
100	101
125	98.2
150	96.1
200	95.2
250	95.2
275	95.2 [Note (2)]

NOTES:

- (1) For welded pipe and tube, the allowable stress values have been multiplied by a factor of 0.85.
- (2) The maximum use temperature shall be 260°C. The value at 275°C is provided for interpolation purposes.

Case 2824

Use of UNS R50400 Titanium Seamless and Welded Tube

Section IV

Approval Date: March 23, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS R50400 titanium seamless and welded tubing in material specification SB-338 Grade 2 be used in the construction of Section IV boilers?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the construction of Section IV boilers, provided the following requirements are met:

(a) The allowable stresses shall be as listed in [Table 1](#) and [Table 1M](#).

(b) The maximum design temperature shall be 500°F (260°C).

(c) For external pressure, Figure NFT-2 of Section II, Part D shall be used.

(d) Welding procedures and performance qualifications shall be conducted in accordance with Section IX.

(e) All other requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, ksi [Note (1)]
-20 to 100	10.0
150	9.4
200	8.7
250	8.0
300	7.2
350	6.7
400	6.2
450	5.8
500	5.3

NOTE: (1) For welded construction, multiply the allowable stress values by 0.85.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, MPa [Note (1)]
-30 to 40	69.0
65	63.8
100	58.7
125	54.3
150	49.9
175	46.5
200	43.1
225	40.5
250	37.8
275	35.3 [Note (2)]

NOTES:

(1) For welded construction, multiply the allowable stress values by 0.85.

(2) The maximum use temperature shall be 260°C. The value at 275°C is provided for interpolation purposes.

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Case 2825

Removal of Nameplate With Certification Mark from Prefabricated or Preformed Parts

Section VIII, Division 1

Approval Date: March 6, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what circumstances may the manufacturer of the completed vessel remove a nameplate that contains the ASME Certification Mark on prefabricated or preformed parts?

Reply: It is the opinion of the Committee that when a nameplate furnished with the Certification Mark on prefabricated or preformed parts may be removed

from the completed pressure vessel if all of the following conditions are satisfied:

(a) The nameplate interferes with further fabrication or service.

(b) The Manufacturer of the completed vessel has agreement from the Authorized Inspector to remove the nameplate.

(c) The removal of the nameplate shall be noted in the Remarks section of the vessel Manufacturer's Data Report.

(d) The removed nameplate shall be destroyed.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2826-1

Automatic Pressure Decay Test in Lieu of Hydrostatic Testing

Section IV

Approval Date: August 14, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a hot water heating boiler or boiler part be tested using an automatic pressure decay test in lieu of hydrostatic test as required by HG-510?

Reply: It is the opinion of the Committee that a hot water heating boiler or boiler part may be tested using an automatic pressure decay test in lieu of hydrostatic test as required by HG-510, provided the following requirements are met:

(a) The test method shall be performed by pressure decay test according to the requirements of the Standard Practice ASTM E2930-13 and Section V, Article 10, Mandatory Appendix VI.

(b) A written procedure shall describe this test and shall be included in the quality control system.

(c) Safety measures according to the local jurisdictional requirements shall be applied to protect personnel conducting and/or witnessing the test.

(d) The maximum water volume shall not exceed 1.0 ft³ (0.028 m³), and the maximum allowable working pressure shall not exceed 160 psi (1103 kPa).

(e) The test pressure shall not be less than the greater of 30 psi (262 kPa) or 1.1 times the design pressure.

(f) Maximum material thickness of any component part shall not exceed 1/2 in. (12.7 mm).

(g) No components of the heating boiler or boiler part that will be subject to pneumatic testing may be constructed of cast iron or cast aluminum.

(h) Nitrogen or clean, dry, oil-free air shall be used.

(i) The maximum differential temperature between the test equipment and the tested part shall not exceed 5°F (3°C).

(j) The minimum room temperature during the pneumatic test shall be at least 60°F (16°C) for the test equipment and the tested part.

(k) This Case number shall be shown on the Manufacturer's Data Report Form.

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Case 2827-2

Low Power Density Laser Beam Welding

Section I; Section VIII, Division 1; Section VIII, Division 2; Section IX

Approval Date: June 29, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may machine and automatic Low Power Density Laser Beam Welding (LLBW) be used?

Reply: It is the opinion of the Committee that machine and automatic Low Power Density Laser Beam Welding can be used, provided the following requirements are met:

(a) Low Power Density Laser Beam Welding (LLBW) shall be defined as a variation of the laser beam welding process in which the coherent light beam employs reduced power density, such that coalescence of materials is achieved by conduction (i.e., melt-in) without keyhole welding.

(b) Low Power Density Laser Beam Welding (LLBW) procedure specification qualification shall be as follows:

(1) The welding procedure specification (WPS) shall be qualified in accordance with the variables defined in [Table 1](#).

(2) The melt-in technique shall be used, and filler material may be added to any portion of the molten weld metal (i.e., filler addition need not be located at the leading edge of the molten weld metal).

(3) Combination of welding processes is permissible in accordance with QW-200.4(b).

(4) Temper bead welding is permissible in accordance with QW-290.2. LLBW heat input shall be calculated as follows:

$$\text{LLBW heat input [J/in. (J/mm)]}$$

$$= \text{Power (W)} \times 60 / \text{Travel speed [in./min (mm/min)]}$$

(c) Qualification of welding operators shall comply with QW-305. Table QW-451 (including Note 3) shall be used for groove weld tension tests and transverse bend tests.

(d) This Case number shall be shown on the welding procedure specification (WPS), procedure qualification record (PQR), and Manufacturer's Data Report.

Table 1
Welding Variables for Low Power Density Laser Beam Welding (LLBW)

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential	
QW-402, Joints	.1	φ Groove design	...	...	X
	.5	+ Backing	...	...	X
	.10	φ Root spacing	...	...	X
	.11	± Retainers	...	...	X
QW-403, Base Metals	.5	φ Group number	...	X	...
	.6	T limits	...	X	...
	.8	T qualified	X	...	...
	.11	φ P-No. qualified	X	...	...
QW-404, Filler Metals	.3	φ Size	...	...	X
	.4	φ F-number	X	...	...
	.5	φ A-number	X	...	...
	.12	φ Classification	...	X	...
	.14	± Filler	X	...	...
	.22	± Consumable insert	...	...	X
	.23	φ Filler metal product form	X	...	...
	.30	φ t	X	...	...
	.33	φ Classification	...	...	X
.50	± Flux	...	...	X	
QW-405, Positions	.1	+ Position	...	...	X
	.2	φ Position	...	X	...
	.3	φ ↑↓ Vertical welding	...	...	X
QW-406, Preheat	.1	Decrease > 100°F (55°C)	X	...	...
	.3	Increase > 100°F (55°C) interpass temperature	...	X	...
QW-407, PWHT	.1	φ PWHT	X	...	...
	.2	φ PWHT (temperature and time range)	...	X	...
	.4	T limits	X	...	...
QW-408, Gas	.1	± Trail or φ composition	...	...	X
	.2	φ Single, mixture, or %	X	...	...
	.3	φ Flow rate	...	...	X
	.5	± or φ Backing flow	...	...	X
	.9	- Backing or φ composition	X	...	...
	.10	φ Shielding or trailing	X	...	...
QW-409, Electrical Characteristics	.1	> Heat input	...	X	...
	.19	φ Pulse	X	...	...
	.20	φ Mode, energy	X	...	...
	.21	Decrease >10% power	X	...	...

Table 1
Welding Variables for Low Power Density Laser Beam Welding (LLBW) (Cont'd)

Paragraph		Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-410, Technique	.3	φ Orifice, cup, or nozzle size	...	...	X
	.5	φ Method cleaning	...	...	X
	.6	φ Method back gouge	...	...	X
	.7	φ Oscillation	...	...	X
	.9	φ Multi- to single-pass/side	...	X	X
	.11	φ Closed to out chamber	X	...	...
	.26	± Peening	...	...	X
	.64	Use of thermal processes	X	...	...
	.66	φ Travel, beam factors	X	...	...
	.67	φ Optical techniques	X	...	...
	.68	φ Type of equipment	X	...	...
	.77	φ Wavelength	X
	.80	φ Spot size	X		

Legend:

- φ = Change
- + = Addition
- = Deletion
- ↑ = Uphill
- ↓ = Downhill

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Case 2830

Use of ASTM A234/A234M Butt Weld Elbows, Grade WPB

Section VIII, Division 1

Approval Date: June 1, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May butt weld elbows manufactured in accordance with ASTM A234/A234M-11a, -13e1, or -14, Grade WPB, and containing the higher limit for manganese be used for Section VIII, Division 1 welded construction?

Reply: It is the opinion of the Committee that butt weld elbows manufactured in accordance with ASTM A234/A234M-11a, -13e1, or -14, Grade WPB, and containing

the higher limit for manganese may be used in Section VIII, Division 1 construction, provided the following requirements are met:

(a) The composition shall conform to Table 1 of ASTM A234/A234M-11a, -13e1, or -14 for Grade WPB, including Note D.

(b) All other requirements of SA-234/SA-234M shall apply.

(c) Allowable stresses shall be those for SA-234/SA-234M, Grade WPB.

(d) This Case number shall be shown on the material marking and documentation, and the Manufacturer's Data Report.

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Case 2831-1

UNS S31266, 24Cr-22Ni-6Mo-2W-Cu-N Super Austenitic Stainless Steel (Class 2)

Section VIII, Division 1; Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S31266 super austenitic stainless steel be used in welded construction conforming to the rules of Section VIII, Division 1 and Division 2, Class 2?

Reply: It is the opinion of the Committee that UNS S31266 super austenitic stainless steel be used in welded construction conforming to the rules of Section VIII, Division 1 and Division 2, Class 2, provided the following requirements are met:

(a) The material shall meet the requirements of SA-182 for forgings, SA-240 for plate, or SA-358 for welded pipe.

(b) Other product forms shall meet the requirements in the product specifications listed in [Table 1](#), and shall meet the room temperature mechanical property requirements in [Table 2](#) and the chemical requirements in [Table 3](#).

(c) The materials listed in [Table 1](#) shall be furnished in the solution annealed condition. The solution annealing shall be performed within the range of 2,085°F to 2,138°F (1 140°C to 1 170°C) followed by liquid quenching or rapid cooling by other means.

(d) The rules for austenitic-stainless steels in Section VIII, Division 1, Subsection C, Part UHA shall apply for Division 1 construction.

(e) The rules for austenitic-stainless steels in Section VIII, Division 2, Part 3 shall apply for Division 2, Class 2 construction.

(f) The design temperature shall not exceed 800°F (426°C).

(g) The maximum allowable design stress values for Division 1 shall be as listed in [Table 4](#) and [Table 4M](#). For welded pipe, tube, or fittings, a 0.85 joint efficiency factor shall be applied to these values.

(h) The maximum allowable stress values for Division 2, Class 2 shall be as listed in [Table 5](#) and [Table 5M](#). For welded pipe, tube, or fittings, a 0.85 joint efficiency factor shall be applied to these values.

(i) In order to satisfy the protection against failure from cyclic loading provisions of Section VIII, Division 2, Class 2, 5.5.1 through 5.5.4, this material shall be considered Table 3-F.3 material.

(j) Tensile and yield strength values are shown in [Table 6](#) and [Table 6M](#).

(k) For physical properties, the following values shall be applied:

(1) thermal expansion: Section II, Part D, Table TE-1, austenitic stainless steel, Group 4 alloys

(2) thermal conductivity and thermal diffusivity: Section II, Part D, Table TCD, high alloy steel, Group L

(3) Poisson's ratio and density: 0.31 and 0.293 lb/in.³ (8 100 kg/m³), respectively

(4) elastic modulus: [Table 7](#) and [Table 7M](#)

(l) For external pressure design, see [Figure 1](#) and [Figure 1M](#) and [Table 8](#) and [Table 8M](#). Values for intermediate temperatures may be obtained by interpolation.

(m) Welding performance and welding procedure qualifications shall be performed in accordance with Section IX. The material shall be considered P-No. 45.

(n) Heat treatment after forming or fabrication is neither required nor prohibited, but when heat treatment is performed, the requirements of (c) shall apply.

(o) For specifications other than SA-182, SA-240, and SA-358, this Case number shall be shown on the documentation and marking of the material.

(p) This Case number shall be shown on the material marking and documentation, and the Manufacturer's Data Report.

Table 1
Product Specifications

Product	Specification
Ferritic and austenitic alloy steel boiler, superheater, and heat exchanger tubes	SA-213/SA-213M
Seamless and welded austenitic stainless steel pipe	SA-312/SA-312M
Single or double welded austenitic stainless steel pipe	SA-813/SA-813M
Stainless steel bars and shapes for use in boilers and other pressure vessels	SA-479/SA-479M
Welded austenitic steel boiler, superheater, heat exchanger, and condenser tubes	SA-249/SA-249M
Wrought austenitic stainless steel pipe fittings	SA-403/SA-403M

Table 2
Mechanical Property Requirements

Minimum tensile strength, ksi (MPa)	109 (750)
Yield strength, 0.2% offset, min., ksi (MPa)	61 (420)
Elongation in 2 in. (50 mm), min. %	35

Table 3
Chemical Requirements

Element	Composition, %
Carbon, max.	0.030
Manganese	2.0–4.0
Phosphorus, max.	0.035
Sulfur, max.	0.020
Silicon, max.	1.00
Nickel	21.0–24.0
Chromium	23.0–25.0
Molybdenum	5.2–6.2
Nitrogen	0.35–0.60
Copper	1.00–2.50
Tungsten	1.50–2.50
Iron	Balance

Table 4
Maximum Allowable Stress Values, Division 1

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, S_m , ksi
100	31.1
150	31.1
200	30.8
250	29.8
300	28.9
350	28.2
400	27.7
450	27.2
500	26.9
550	26.6
600	26.3
650	26.1
700	25.9
750	25.7
800 [Note (1)]	25.4

NOTE: (1) The maximum use temperature is 800°F.

Table 4M
Maximum Allowable Stress Values, Division 1

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, S_m , MPa
40	215
65	215
100	210
125	204
150	199
175	195
200	191
225	188
250	186
275	184
300	182
325	181
350	179
375	178
400	177
425	175
450 [Note (1)]	174

NOTE: (1) The maximum use temperature is 426°C. The value at 450°C is for interpolation only.

Table 5
Maximum Allowable Stress Values, Division 2, Class 2

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, S_m , ksi
100	40.7
150	40.7
200	40.7
250	40.7
300	40.7
350	40.7
400	40.7
450	40.7
500	40.7
550	40.7
600	40.7
650 [Note (1)]	40.6
700 [Note (1)]	40.4
750 [Note (1)]	40.3
800 [Note (1)], [Note (2)]	40.1

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is possible. These higher stress values exceed 66 $\frac{2}{3}$ % but do not exceed 90% of the yield strength temperature. Use of these stresses are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction. Section II, Part D, Table Y-2 lists multiplying factors that, when applied to the yield strength values shown in Table Y-1, give allowable stress values that will result in lower levels of permanent strain.
- (2) The maximum use temperature is 800°F.

Table 5M
Maximum Allowable Stress Values, Division 2, Class 2

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, S_m , MPa
40	280
65	280
100	280
125	280
150	280
175	280
200	280
225	280
250	280
275	280
300	280
325	280
350	280
375 [Note (1)]	279
400 [Note (1)]	278
425 [Note (1)]	277
450 [Note (1)], [Note (2)]	275

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is possible. These higher stress values exceed 66 $\frac{2}{3}$ % but do not exceed 90% of the yield strength temperature. Use of these stresses are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction. Section II, Part D, Table Y-2 lists multiplying factors that, when applied to the yield strength values shown in Table Y-1, give allowable stress values that will result in lower levels of permanent strain.
- (2) The maximum use temperature is 426°C. The value at 450°C is for interpolation only.

**Table 6
Tensile and Yield Strengths**

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi	Tensile Strength, ksi
100	61.0	109
150	56.2	109
200	53.7	108
250	51.7	104
300	50.0	101
350	48.7	98.9
400	47.6	96.9
450	46.8	95.3
500	46.1	94.0
550	45.7	92.9
600	45.3	92.1
650	45.1	91.3
700	44.9	90.6
750	44.7	89.8
800 [Note (1)]	44.5	88.9

NOTE: (1) The maximum use temperature is 800°F.

**Table 7
Modulus of Elasticity**

Temperature, °F	E, ksi × 10 ⁻³
-325	29.6
-200	28.8
-100	28.2
70	27.2
100	27.0
200	26.4
300	25.8
400	25.2
500	24.6
600	24.0
700	23.4
800	22.8
900	22.2
1,000	21.6

**Table 7M
Modulus of Elasticity**

Temperature, °C	E, MPa × 10 ⁻³
-200	204
-125	198
-75	195
25	187
100	182
150	178
200	174
250	171
300	167
350	163
400	159
450	156
500	152
550	148

**Table 6M
Tensile and Yield Strengths**

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa	Tensile Strength, MPa
40	421	752
65	388	752
100	367	736
125	355	715
150	344	697
175	336	683
200	329	670
225	324	660
250	319	651
275	316	644
300	314	638
325	312	633
350	311	628
375	310	624
400	308	619
425	307	614
450 [Note (1)]	306	607

NOTE: (1) The value at 450°C is for interpolation only. The maximum use temperature is 426°C.

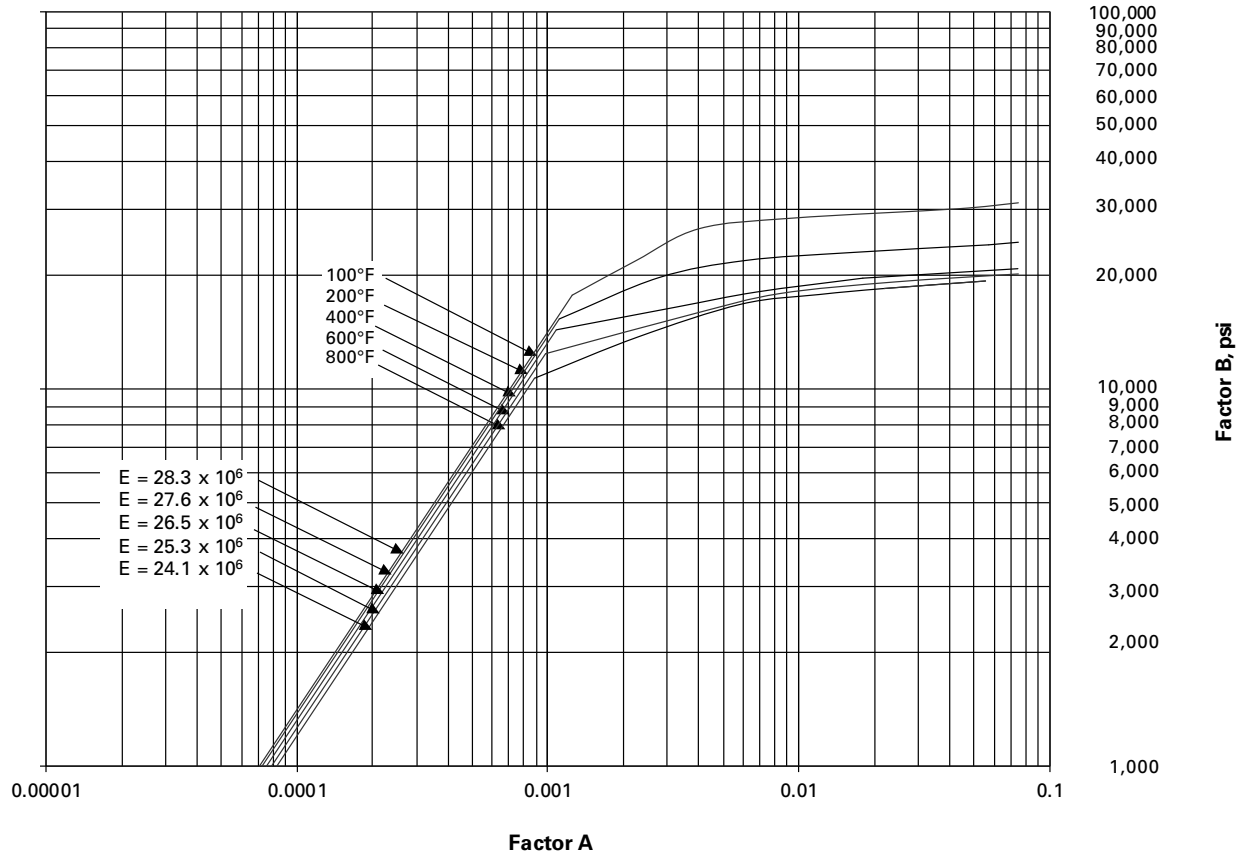
Table 8
Tabular Values for Figure 1

Temperature, °F	A	B, psi
Up to 100	1.00 E-05	1.42 E+02
	7.07 E-04	1.00 E+03
	1.00 E-04	1.42 E+03
	1.25 E-03	1.77 E+04
	2.24 E-03	2.18 E+04
	4.01 E-03	2.66 E+04
	9.49 E-03	2.83 E+04
	4.29 E-02	3.00 E+04
7.50 E-02	3.11 E+04	
200	1.00 E-05	1.38 E+02
	7.25 E-04	1.00 E+03
	1.00 E-04	1.38 E+03
	1.11 E-03	1.53 E+04
	2.76 E-03	1.97 E+04
	6.14 E-03	2.19 E+04
	1.64 E-02	2.30 E+04
	5.72 E-02	2.41 E+04
7.50 E-02	2.45 E+04	
400	1.00 E-05	1.33 E+02
	7.55 E-04	1.00 E+03
	1.00 E-04	1.33 E+03
	1.08 E-03	1.43 E+04
	3.23 E-03	1.65 E+04
	6.78 E-03	1.81 E+04
	1.80 E-02	1.97 E+04
	7.47 E-02	2.08 E+04
600	1.00 E-05	1.27 E+02
	7.91 E-04	1.00 E+03
	1.00 E-04	1.27 E+03
	9.79 E-04	1.24 E+04
	3.77 E-03	1.58 E+04
	8.38 E-03	1.79 E+04
	2.41 E-02	1.92 E+04
	7.50 E-02	2.02 E+04
800	1.00 E-05	1.21 E+02
	8.30 E-04	1.00 E+03
	1.00 E-04	1.21 E+03
	8.84 E-04	1.07 E+04
	2.28 E-03	1.37 E+04
	5.90 E-03	1.68 E+04
	1.21 E-02	1.78 E+04
	2.19 E-02	1.85 E+04
	5.55 E-02	1.93 E+04
	7.50 E-02	1.97 E+04

Table 8M
Tabular Values for Figure 1M

Temperature, °C	A	B, MPa
Up to 38	1.00 E-05	9.75 E-01
	1.03 E-04	1.00 E+01
	1.25 E-03	1.22 E+02
	2.24 E-03	1.51 E+02
	4.01 E-03	1.83 E+02
	9.49 E-03	1.95 E+02
	4.29 E-02	2.07 E+02
	7.50 E-02	2.14 E+02
93	1.00 E-05	9.51 E-01
	1.05 E-04	1.00 E+01
	1.11 E-03	1.06 E+02
	2.76 E-03	1.36 E+02
	6.14 E-03	1.51 E+02
	1.64 E-02	1.58 E+02
	5.72 E-02	1.66 E+02
	7.50 E-02	1.69 E+02
204	1.00 E-05	9.51 E-01
	1.09 E-04	1.00 E+01
	1.08 E-03	9.88 E+01
	3.23 E-03	1.13 E+02
	6.78 E-03	1.24 E+02
	1.80 E-02	1.35 E+02
	7.47 E-02	1.43 E+02
	316	1.00 E-05	8.72 E-01
1.15 E-04		1.00 E+01
9.79 E-04		8.54 E+01
3.77 E-03		1.09 E+02
8.38 E-03		1.23 E+02
2.41 E-02		1.32 E+02
7.50 E-02		1.39 E+02
427		1.00 E-05	8.30 E-01
	1.20 E-04	1.00 E+01
	8.84 E-04	7.35 E+01
	2.28 E-03	9.46 E+01
	5.90 E-03	1.16 E+02
	1.21 E-02	1.23 E+02
	2.19 E-02	1.27 E+02
	5.55 E-02	1.33 E+02
7.50 E-02	1.36 E+02	

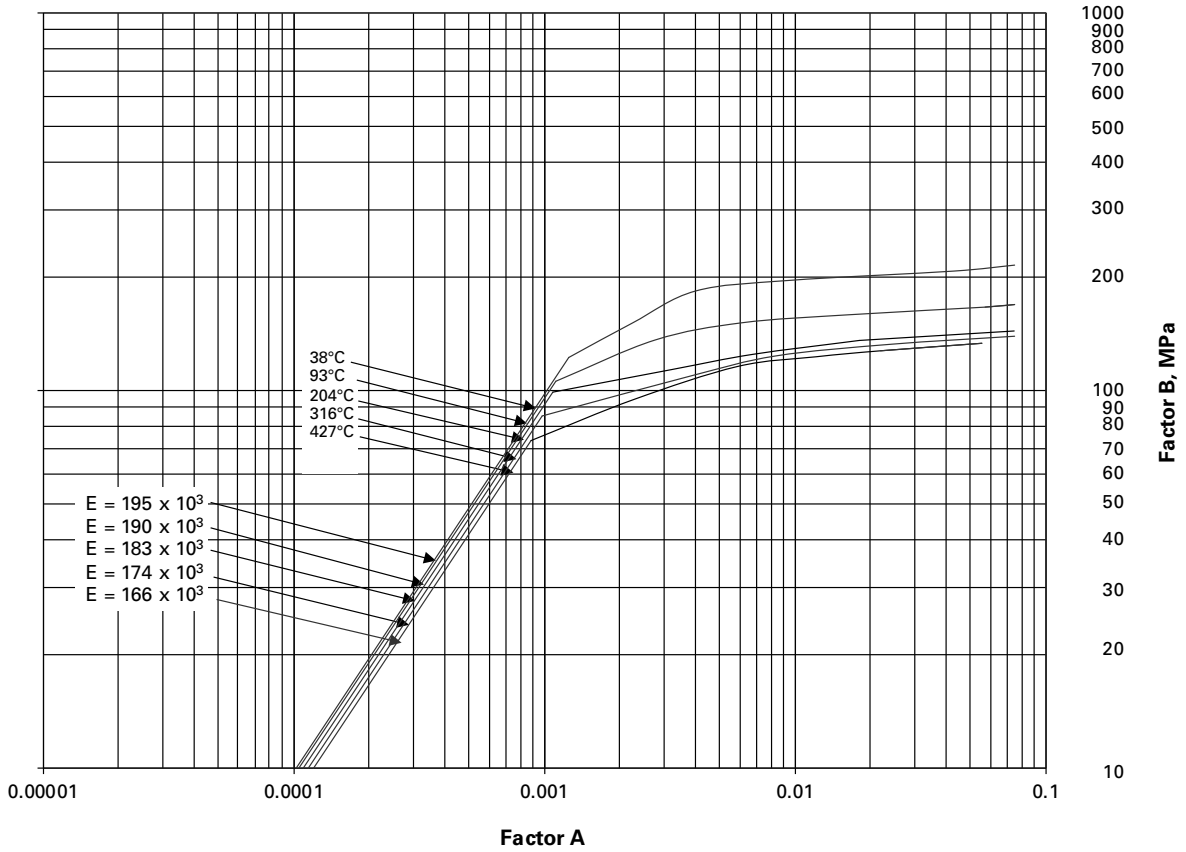
Figure 1
External Pressure Design for Austenitic Stainless Steel 24Cr-17Ni-6Mn-4.5Mo-N (UNS S34565)



GENERAL NOTES:

- (a) The external pressure chart assigned does not account for the reduction of buckling strength due to creep under long-term loads. The effect of creep shall be considered at temperatures for which allowable stress are shown italicized in Section II, Part D, Tables 1A, 1B, 2A, 2B, 5A, and 5B.
- (b) The external pressure chart assigned for a particular material is obtained from the stress Tables 1A, 1B, 2A, 2B, 5A, and 5B under the column "External Pressure Chart No." for that material and is mandatory with the exception of Tables 5A and 5B.

Figure 1M
External Pressure Design for Austenitic Stainless Steel 24Cr-17Ni-6Mn-4.5Mo-N (UNS S34565)



GENERAL NOTES:

- (a) The external pressure chart does not account for the reduction of buckling strength due to creep under long-term loads. The effect of creep shall be considered at temperatures for which allowable stress are shown italicized in Section II, Part D, Tables 1A, 1B, 2A, 2B, 5A, and 5B.
- (b) The external pressure chart assigned for a particular material is obtained from the stress Tables 1A, 1B, 2A, 2B, 5A, and 5B under the column "External Pressure Chart No." for that material and is mandatory with the exception of Tables 5A and 5B.

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Case 2832

WPS Qualification for Friction Taper Hydro Pillar (FTHP) Welding

Section IX

Approval Date: July 21, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a welding procedure specification (WPS) for the friction taper hydro pillar (FTHP) welding process be qualified in accordance with Section IX?

Reply: It is the opinion of the Committee that a welding procedure specification (WPS) for the friction taper hydro pillar (FTHP) welding process may be qualified in accordance with Section IX, provided the following conditions are met:

(a) The variables applicable for qualifying a welding procedure specification (WPS) for FTHP welding shall be those shown in [Table 1](#), with new variables unique to FTHP welding described in detail in the Notes.

(b) The terminology used in the variable descriptions for the FTHP welding process are as defined as follows and illustrated in [Figure 1](#).

forging force: the compressive force applied to the consumable rotating tool after the friction phase of the welding cycle is completed.

forging phase: the portion of the friction welding cycle during which the forging force is applied to the interface.

forging time: the duration of time when the forging force is applied.

friction force: the compressive force applied by the consumable rotating tool at the hole base diameter during the friction phase of the welding cycle.

friction phase: the portion of the welding cycle during which the heat necessary for welding is generated by the relative motion and application of the friction force at the interface.

friction taper hydro pillar (FTHP) welding: an automatic, solid state welding process completed by rotating a consumable tool (with or without a taper) inside a prepared blind hole (with a matching shape) in the base metal while applying downward axial pressure. The heat of friction created between the rotating tool and the prepared surface of the hole forms a plasticized interface joining the rotating tool to the hole in the base

metal once the tool rotation has ceased. The FTHP welding process is primarily used for repairing a hole in a pipe where material has been removed for metallurgical testing.

friction time: the duration of the friction phase.

rotational speed: the rpm of the consumable rotating tool during the friction phase.

upset distance: the total loss of axial length of the consumable rotating tool from the point of initial contact until the completion of the weld.

weld flash: the material that is displaced from the friction weld interface.

(c) The welding procedure shall be qualified by tensile testing and bend testing.

(1) The tensile test requirement shall be completed by removing two tensile test specimens from the test coupon with the weld area located in the center, and the axis of the weld transverse to the width of each tensile test specimen as shown in [Figure 2](#). The tensile test specimens shall be removed from the test coupon with one face of each specimen common to the center of the weld, and prepared for tensile testing as shown in [Figure QW-462.1\(a\)](#).

(2) The bend test requirement shall be completed by removing three bend test specimens from the test coupon with the weld located in the center, and the axis of the weld perpendicular to the face of each bend test specimen as shown in [Figure 3](#). The three bend test specimens shall be removed from near the weld surface, the middle of the weld depth, and $\frac{1}{8}$ in. (3 mm) upward from the bottom of the weld.

(d) The FTHP welding process shall be used only for the repair of holes in piping where material has been removed for metallurgical testing. The FTHP welding process shall not be used for other types of repairs such as defects in boiler drums or shells of pressure vessels under the provisions of this Case.

(e) This Case number shall be shown on the Welding Procedure Specification (WPS), the Procedure Qualification Record (PQR), and the Welding Operator Performance Qualification (WPQ).

Table 1
Welding Variables for Friction Taper Hydro Pillar (FTHP) Welding

Paragraph		Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-402, Joints	.X(a)	ϕ Hole depth > $\pm 10\%$ [Note (1)]			X
	.X(b)	ϕ Hole base diameter $\pm 10\%$ [Note (2)]	X		
	.X(c)	ϕ Hole base radius [Note (3)]	X		
	.X(d)	ϕ Hole taper angle ± 0.5 deg [Note (4)]	X		
	.X(e)	– Retaining ligament > 10% [Note (5)]			X
QW-403, Base Metals	.19	ϕ Type/grade	X		
QW-406, Preheat	.1	Decrease > 100°F	X		
QW-407, PWHT	.1	ϕ PWHT	X		
QW-408, Gas	.11	\pm Gas shielding	X		
QW-410, Technique	.17	ϕ Welding equipment			X
	.31	ϕ Joint cleaning methods			X
	.X(a)	ϕ Consumable rotating tool [Note (6)]	X		
	.X(b)	ϕ Rotating tool operation [Note (7)]	X		

GENERAL NOTE: The Xs in paragraph and figure references are to be determined.

NOTES:

- (1) An increase in the hole depth greater than $\pm 10\%$ (see Figure QW-461.XX)
- (2) A change in the hole base diameter greater than $\pm 10\%$ (see Figure QW-461.XX)
- (3) A change in the hole base radius greater than $+0.01$ in./ -0.0 in. ($+0.25$ mm/ -0.0 mm) (see Figure QW-461.XX)
- (4) A change in the hole taper angle greater than ± 0.5 deg (see Figure QW-461.XX)
- (5) A reduction of the retaining ligament > 10% (see Figure QW-461.XX)
- (6) A change in the consumable rotating tool characteristics beyond the following limits (see Figure QW-461.XX):
 - (a) taper angle greater than ± 0.5 deg
 - (b) tool face radius greater than $+0.01$ in./ -0.0 in. ($+0.25$ mm/ -0.0 mm)
 - (c) tool face diameter greater than $+5\%$ / -0% , provided the tool face diameter is not less than 90% nor greater than 95% of the hole base diameter
 - (d) reduction in taper length to less than 140% of the hole depth
 - (e) material specification and grade or nominal chemistry
- (7) A change in the operating characteristics of the consumable rotating tool beyond the following limits (see QG-109.2):
 - (a) friction force greater than $\pm 5\%$
 - (b) rotational rpm greater than $\pm 10\%$
 - (c) reduction of forging force to less than friction force
 - (d) reduction in forging time to less than 25 sec
 - (e) upset distance greater than $+5\%$. Continuous circumferential weld flash and some portion of the tapered length of the consumable rotating tool shall be visible after welding.

**Figure 1
Terminology**

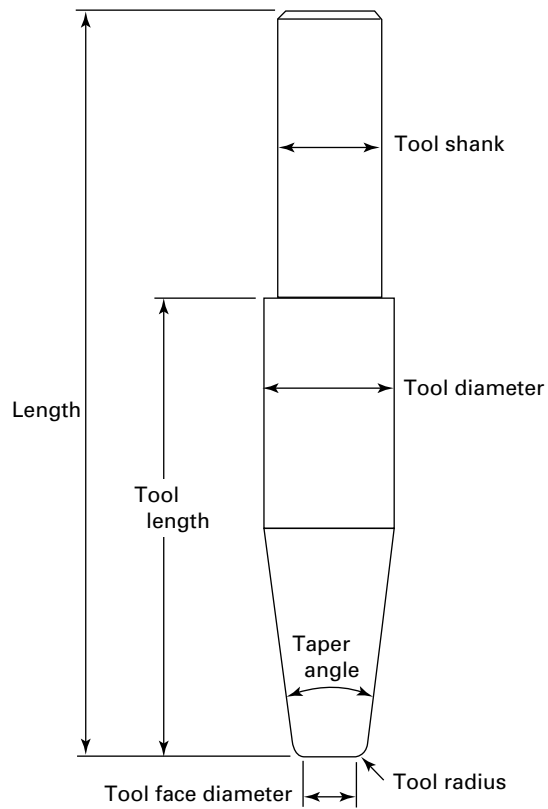
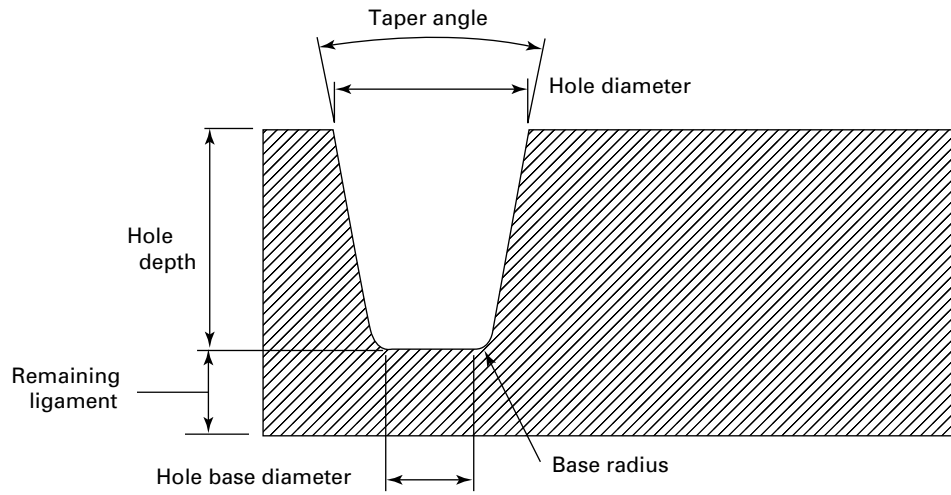


Figure 2
Tensile Test Specimen Removal

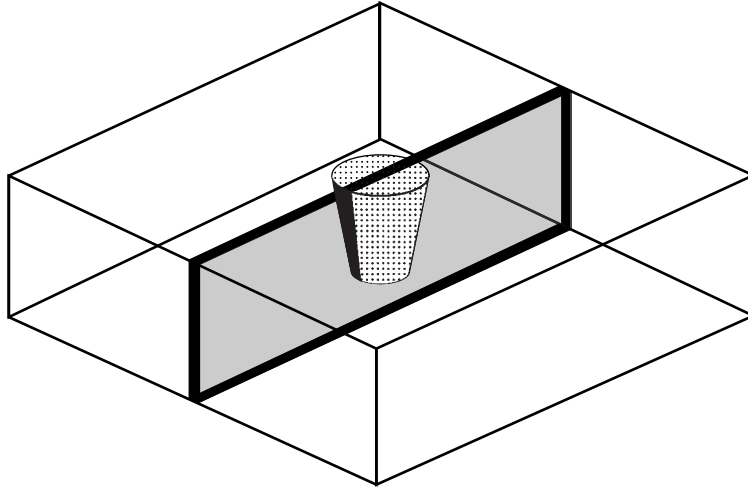
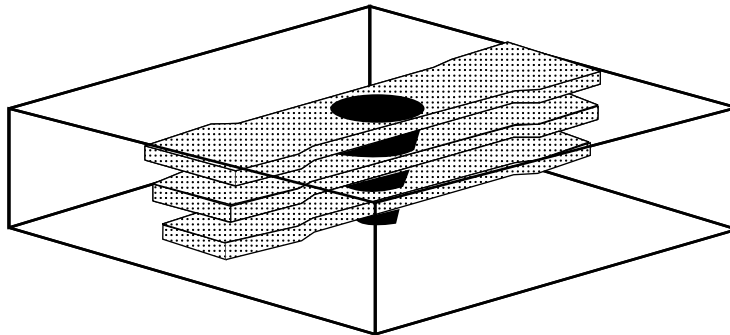


Figure 3
Bend Test Specimen Removal



Case 2833

Design of Hubless Integral Flanges Using Part 4.16

Section VIII, Division 2

Approval Date: July 15, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What values of F , f , V , and h shall be used for the design of a hubless flange (where $g_o = g_1$) as shown in Figure 4.16.1, illustration (b) of Section VIII, Division 2?

Reply: It is the opinion of the Committee that when designing a hubless flange (where $g_o = g_1$) as shown in Figure 4.16.1, illustration (b) of Section VIII Division 2, the following conditions shall apply:

(a) The following values shall apply:

$$F = 0.908920$$

$$f = 1.0$$

$$V = 0.550103$$

(b) The value of h used to calculate I_p in Table 4.16.7 shall be determined as follows:

$$0.7 \sqrt{\frac{B}{2} g_o}$$

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2834

Hillside Nozzle in Spherical Shell or Hemispherical Head in 4.5.11

Section VIII, Division 2

Approval Date: July 15, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May Section VIII, Division 2, 4.5.11 be applied for a hillside nozzle in a spherical shell or a hemispherical head?

Reply: It is the opinion of the Committee that Section VIII, Division 2, 4.5.11 may be applied for a hillside nozzle in a spherical shell or a hemispherical head, provided the following requirements are met:

(a) The design procedure in 4.5.11 shall be used with R_{nc} , which is calculated using equations (4.5.63) through (4.5.66) in Section VIII, Division 2 by substituting D_R for D_X .

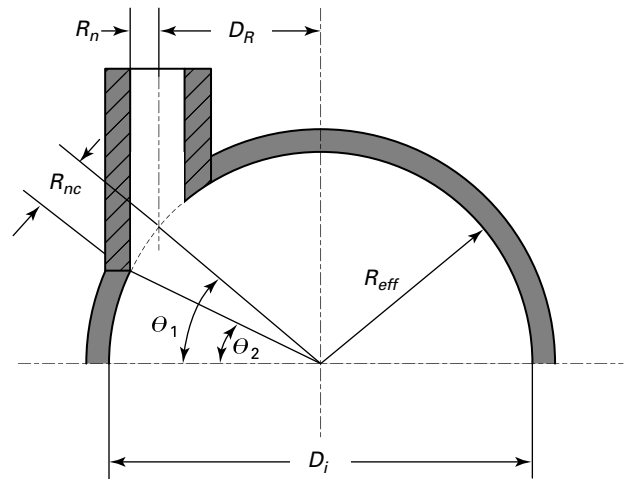
D_R = distance from the head centerline to the nozzle centerline

R_{eff} = effective pressure radius
= $0.5D_i$

R_{ncl} = radius of nozzle opening in the spherical shell or hemispherical head along the long arc for hillside nozzle (see [Figure 1](#))

(b) This Case number shall be shown in the documentation and on the Manufacturer's Data Report.

Figure 1
Hillside Nozzle in Spherical Shell or Hemispherical Head



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Case 2835

Heat-Affected Zone Impact Testing in Weld Procedure Qualification, UG-84(g)(2)

Section VIII, Division 1

Approval Date: September 15, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may welding procedure specifications qualified with toughness testing in accordance with the requirements of the 1988 Edition and subsequent Editions and Addenda of Section VIII, Division 1 be acceptable for construction without performing additional impact testing to meet the requirements of UG-84(g)(2)?

Reply: It is the opinion of the Committee that welding procedure specifications qualified with toughness testing in accordance with the requirements of the 1988 Edition

and subsequent Editions and Addenda of Section VIII, Division 1 are acceptable for construction without performing additional impact testing to meet the requirements of UG-84(g)(2), provided the following requirements are met:

(a) The welding procedure specification has been previously qualified and has met the requirements of Section VIII, Division 1 prior to the 2013 Edition.

(b) The existing welding procedure specification may be used until the 2017 Edition of Section VIII, Division 1 goes into effect on January 1, 2018.

(c) This Case number shall be recorded on the Manufacturer's Data Report.

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Case 2836-4

Manufacture of a Hoop-Wrapped, Wire-Reinforced Cylindrical Pressure Vessel

Section VIII, Division 3

Approval Date: January 6, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a hoop-wrapped, wire-reinforced cylindrical pressure vessel whose cylindrical shell carries the pressure end load be produced using the rules of Section VIII, Division 3?

Reply: It is the opinion of the Committee that a hoop-wrapped, wire-reinforced cylindrical pressure vessel whose shell carries the end load may be produced using the rules of Section VIII, Division 3, provided the following additional requirements are met:

- (a) The vessel shall be comprised of a monobloc cylindrical seamless shell with integrally forged heads.
- (b) The shell shall meet the Charpy V-notch impact requirements of Table KM-234.2(a).
- (c) The vessel heads shall not be wrapped.
- (d) The vessel shall be wound in the hoop direction with a helix angle of the winding less than 1 deg.
- (e) The maximum gap between the wires in the longitudinal direction of the vessel shall be the lesser of 5% of the wire width or 0.010 in. (0.25 mm).
- (f) The cylindrical shell shall carry the end load due to pressure.
- (g) The design temperature shall not exceed 200°F (93°C).
- (h) No welding is permitted on the vessel, including the shell with integrally formed heads, or the wire. The wire winding shall be a single continuous length of wire.
- (i) The design pressure of the shell with the wire wraps shall be demonstrated using finite element analysis in accordance with the rules of KD-230 or Mandatory Appendix 9.
- (j) Under design conditions, the average stress intensity over the cross section of each individual wire at any point in the winding shall not exceed the yield strength of the wire, S_y . Under all operational loading conditions, including hydrostatic and autofrettage loading, each individual wire at any point in the winding shall not exceed the yield strength of the wire, S_y .

(k) The calculated collapse pressure of the shell alone shall be equal to or greater than 120% of the design pressure of the vessel. The calculation shall be performed using the minimum specified values of yield and tensile strengths. If an elastic-plastic analysis is used, strain hardening may be considered.

(l) The design fatigue life of the winding shall be calculated in accordance with KD-933. A design fatigue curve derived in accordance with KD-932 shall be used. For environmental conditions not covered by the derived design fatigue curve, the Manufacturer shall obtain supplementary fatigue test data.

(m) For all components other than the winding, the number of design cycles shall be determined in accordance with KD-140.

(n) For every combination of essential variables used in production of the vessel, a unique Wire Winding Procedure Specification shall be prepared. The essential variables shall include the following:

- (1) wire specification, grade, and size
- (2) volumetric expansion of the prototype vessel
- (3) vessel dimensions
- (4) description of the winding machine
- (5) how tension is applied, controlled, and measured during winding.

The application of the winding onto the cylinder shall be carried out in a special winding machine equipped with devices that are able to control and measure the tensile force used for applying the wire. This force shall also be recorded on a diagram that shall be filed by the Manufacturer for each vessel. The measuring devices shall be calibrated at least every six months or any time there is reason to believe that the measurements are erroneous. The wire end shall be properly locked to prevent unwrapping.

(o) *Wire Winding Procedure Specification Qualification.* It shall be the Manufacturer's responsibility to qualify the Wire Winding Procedure Specification according to the requirements of this Case and document the results. Requalification shall follow the same procedure as the original qualification. Refer to Form WWPV-1.

(1) Vessels used to qualify the Wire Winding Procedure Specification shall be designated as prototype vessels. Prototype vessels used to qualify or requalify a Wire Winding Procedure Specification shall meet all of

the requirements of Division 3 but shall not be Code stamped.

(2) Each vessel used for qualifying or requalifying the Wire Winding Procedure Specification shall be fabricated and examined in accordance with the requirements that follow, and the results documented on a Manufacturer's Data Report with the notation "Prototype Qualification."

(p) *Volumetric Expansion Tests.* Each vessel produced, including the prototype vessel, shall be subjected to a volumetric expansion test using a test fluid that complies with the requirements of KT-320.

(1) The volume of liquid used to fill the vessel at atmospheric pressure and temperature shall be compared with that required to fill it at the design pressure and at the same temperature. Care shall be taken to eliminate air pockets to ensure accuracy. The volume of liquid used in each instance shall be determined by any appropriate means, such as a weigh tank that has been calibrated to an accuracy of $\pm 0.2\%$. The results of this test shall be subsequently used in the production volumetric expansion test.

(2) Alternatively, the volumetric expansion may be determined by measuring the overall length of the vessel and its circumference at 5 ft (1.5 m) intervals along its length, with a minimum of three such determinations being made. All measurements shall be made with instruments that have been calibrated to an accuracy of $\pm 0.05\%$. These measurements shall be taken with the vessel filled with liquid at atmospheric pressure and at design pressure, both at the same temperature. The measurements thus made shall be subsequently used in the production volumetric expansion test.

(3) Acceptance criteria shall be in accordance with (q)(2) of this Case.

(q) *Production Testing.* Each vessel produced shall be subject to the tests required by (1) and (2) and shall conform to the specified requirements with results recorded on the Production Test Reports.

(1) *Hydrostatic Test.* For vessels to be installed at a fixed location, a hydrostatic test to a pressure at least 1.25 times the design pressure shall be performed on each vessel. For vessels to be used in transport service, a hydrostatic test to a pressure at least 1.25 times the design pressure or 1.5 times the service or working pressure, whichever is greater, shall be performed on each vessel; see KT-310. This test may be combined with any hydrostatic pressurization procedure used to provide a prestress in the individual layers. The hydrostatic test shall be staged with examinations in (r) of this Case before the production volumetric expansion test. The vessel Production Test Report shall become part of the Manufacturer's Construction Records.

(2) *Volumetric Expansion Test.* A volumetric expansion test shall be performed on every vessel in accordance with the requirements of the Wire Winding Procedure Specification Qualification; see (o) and (p) of this Case.

The results of these tests shall not differ by more than 5% from the values recorded in the original Prototype Qualification Test Report and Wire Winding Procedure Specification after correcting for any variance in material properties.

(r) *Examinations.* Each vessel shall be subjected to the examinations required by (1) and (2) and shall conform to the specified requirements, with results recorded in Production Test Reports. Examinations detailed in (1) and (2) shall be carried out before the hydrostatic test. The Vessel Production Test Report shall become part of the Manufacturer's Construction Records.

(1) *Design Dimensions Examination.* Each vessel shall be examined for conformance with dimensions and tolerances shown on the design drawings.

(2) *Metallic Surface Examination.* The requirements of KE-400 cannot be applied to these vessels as examination of internal surfaces and external surfaces under the winding are not practical after hydrostatic test. The external surface of the vessel shall be inspected before winding of the vessel. The internal surfaces shall be inspected prior to forming of the heads on the end of the vessel. It shall be demonstrated by a fracture mechanics approach that the minimum detectable flaw size will not grow during the hydrostatic test to a size not accounted for in the analysis.

(s) Form WWPV-2, Manufacturer's Data Report for Wire Wound Pressure Vessels, shall be completed for vessels produced under this Case. Refer to Table 1 for instructions. Form K-1, Manufacturer's Data Report For High Pressure Vessels, shall not be used for vessels manufactured using this Case.

FORM WWPV-1 RECOMMENDED FORM FOR QUALIFYING THE WIRE WINDING DESIGN AND THE WIRE WINDING PROCEDURE SPECIFICATION USED IN MANUFACTURING WIRE WOUND REINFORCED PRESSURE VESSELS
As required by the Provisions of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 3, Case 2836

Qualification Test Report No. _____

Wire Winding Procedure No. _____

A change in any of the essential variables denoted by an asterisk below requires a new Wire Winding Procedure Specification.

*Wire Spec / Grade / Size _____

*Variables of Winding Process

Helix Angle _____ (measured on cylinder between axis and band path)

Tension: Per strand (End), Roving, or Band (specify which) _____ per _____

Method of Control _____ Program _____

*Inner Shell [Material, Grade, and Thickness, See Note (1)] _____

*Shell Size and Configuration _____
[OD, Length, Head Configuration (spherical, elliptical, etc.)]

*Volumetric Expansion _____

Qualification Vessel Designation Number _____

Design Report Number _____

Original Qualification Report Number _____

If Requalification, Requalification Report Number _____

ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 3 _____
(Year, Case No.)

We certify that the statements in this Specification are correct:

Date _____ Signed _____

By _____

Certificate of Authorization Number _____

NOTE:

(1) Where range of values or a tolerance applies, state the applicable range or tolerance.

CERTIFICATION BY SHOP INSPECTOR OF QUALIFICATION OF WIRE WINDING DESIGN AND WIRE WINDING PROCEDURE SPECIFICATION

Wire Winding Procedure Specification of _____ at _____ for _____ process of manufacturing vessel(s) described in User's Design Specification Number _____ and Manufacturer's Design Report Number _____

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by _____ of _____ have inspected the pressure vessel and witnessed tests described in the Qualification Test Report of the Wire Winding Design and Wire Winding Procedure Specification and state that, to the best of my knowledge and belief, the Manufacturer has constructed this part in accordance with the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 3, and the Wire Winding Design and Wire Winding Procedure Specification being qualified. By signing this certificate, neither the inspector nor his employer make any warranty, expressed or implied, concerning the design or procedure covered by this Qualification Test Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or loss of any kind arising from or connected with this inspection.

Date _____ Signed _____ Commissions _____
(Authorized Inspector) [National Board (incl. endorsements)]

FORM WWPV-2 MANUFACTURER'S DATA REPORT FOR WIRE WOUND PRESSURE VESSELS
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 3, Case 2836

1. Manufactured and certified by (name and address of Manufacturer)
2. Manufactured for (name and address of purchaser)
3. Operating location (where installed and where transported)
4. Type (horizontal/vertical), (Manufacturer's serial no.), (CRN), (National Board No.), (year built)
Drawing no., Prepared by
5. User's Design Specification on file at
Certified by, P.E. state, Reg. no.
6. Manufacturer's Design Report on file at
Certified by, P.E. state, Reg. no.
6a. Wire Winding Procedure Specification on file at
Qualification Report No., Dated, Latest requalification date
7. Material, Impact tested at °F
8. ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 3 (year), (Code Case no.)
9. Service
10. Restrictions and warnings
cycles at psig at °F
11. Construction
Prestress method
12. Size and configuration (I.D.), (length), (thickness), (cylindrical, spherical, other)
13. Supports and attachments
14. Design pressure psi at maximum coincident metal temperature °F
Service pressure at vessel/contents temperature of 70°F (20°C)
Maximum metal vessel temperature °F at psi
Minimum design metal vessel temperature °F at psi
15. Test pressure psi at °F
(pneum./hydro./combination)
Performed in the position [fluid(s) used in test]
16. Closures
17. Connections, or provisions, for overpressure relief

(7/21)

FORM WWPV-2 (Back)

18. Nozzles and connections

Purpose (Inlet, Outlet Drain)	Quantity	Diameter or Size	Type	Material	Nominal Thickness	Reinforcement Material	How Attached	Location
(33) (34) (35)		(34)	(34) (36)	(12)	(29)			(35)

19. Manufacturer's Partial Data Reports, properly identified and signed by commissioned Inspectors, have been furnished for the following components _____ (37)

20. Remarks _____ (16) _____ (41)

CERTIFICATE OF SHOP COMPLIANCE	
We certify that the statements in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 3, Case 2836.	
U3 Certificate of Authorization no. _____ expires _____, _____. (Stamped "U3" only)	
Date _____ Co. name _____ (38) (Manufacturer)	Signed _____ (38) (representative)
CERTIFICATE OF SHOP INSPECTION	
I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of _____ and employed by _____ of _____, have inspected the pressure vessel described in this Manufacturer's Data Report on _____, _____, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this part in accordance with the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 3, Case 2836. By signing this certificate, neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the part described in this Manufacturer's Data Report. Furthermore, 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.	
Date _____ Signed _____ (39) (Authorized Inspector)	Commissions _____ (40) [National Board (incl. endorsements), state, prov., and no.]

Table 1
Instructions for the Preparation of Manufacturer's Data Report Form WWPV-2

Ref. to Circled No. in the Form	Instruction
(1)	Name and street address of Manufacturer, as shown on Manufacturer's ASME Code Certificate of Authorization.
(2)	Name and address of purchaser.
(3)	Name of user and address of the Owner of the vessel.
(4)	Type of vessel, such as horizontal or vertical, separator, heat exchanger, reactor, storage, etc.
(5)	An identifying Manufacturer's serial number marked on the vessel (or vessel part) (see KS-120).
(6)	Canadian registration number where applicable.
(7)	Where applicable, National Board Number from Manufacturer's Series of National Board Numbers. National Board Number shall not be used for owner-inspected vessels.
(8)	Indicate drawing numbers, including revision numbers, which cover general assembly and list materials. For Canadian registration, also include the number of the drawing approved by Provincial authorities.
(9)	Organization that prepared drawing.
(10)	To be completed by the Manufacturer to show the disposition of the User's Design Specification and the Manufacturer's Design Report, and to identify the registered Professional Engineers who certify them.
(11)	State of the U.S.A. or province of Canada, as applicable.
(12)	Show the complete ASME specification number and grade of the actual material used in the vessel part. Material is to be as designated in Section VIII, Division 3. Exceptions: A specification number for a material not identical to an ASME specification may be shown only if such material meets the criteria in the Foreword of Section VIII, Division 3. When material is accepted through a Code Case, the applicable Case number shall be shown.
(13)	Issue date of Section VIII, Division 3 under which vessel or vessel part was manufactured.
(14)	All Code Case numbers when vessel is manufactured according to any Cases.
(15)	Describe contents or service of the vessel.
(16)	Additional comments, including any Code restrictions on the vessel or any unusual Code or jurisdictional requirements that have been met, such as those noted in (17), (18), (20), (21), and (31). Indicate corrosion or erosion allowance.
(17)	Show need for start-up or shutdown temperature and/or controlled rate of heating or cooling, maximum temperature of any part.
(18)	Show results of fatigue analysis, number of cycles, limitations, or restrictions.
(19)	Type of longitudinal joint in cylindrical section, or any joint in a sphere (e.g., Type No. 1 butt or seamless).
(20)	When heat treatment is performed by the Manufacturer, give temperature and time. Explain any special cooling procedure and other pertinent heating during fabrication.
(21)	Indicate examination applied. Methods, location, and results should be included under Remarks.
(22)	Prestress, method, verification, etc.
(23)	Indicate inside diameter.
(24)	The shell length shall be shown as the overall length between closure.
(25)	Thickness is the nominal thickness of the material used in the fabrication of the vessel. It includes corrosion allowance.
(26)	Indicate provisions for support of the vessel and any attachments for superimposed equipment.
(27)	Show design pressure for which vessel is constructed (see KG-311). Other internal or external pressures with coincident temperatures shall be listed where applicable.
(28)	Show maximum coincident metal temperatures permitted for vessel at the design pressures.
(29)	Show service pressure/working pressure for which the vessel is constructed.
(30)	Show minimum design metal temperature at coincident pressure. List if more than one set.
(31)	Show hydrostatic or other tests made with specified test pressure at top of vessel in the test position that applies (pneumatic, hydrostatic, or combination test pressure). Indicate if vessel was tested in the vertical position.
(32)	Bolts used to secure removable head(s), closures, or seals of vessel.
(33)	Indicate nozzle or other opening that is designated for pressure relief (see Part KR).
(34)	Show other nozzles and openings by size, type, and purpose. See (36).
(35)	Show opening designated for inspection. Show location.

Table 1
Instructions for the Preparation of Manufacturer's Data Report Form WWPV-2 (Cont'd)

Ref. to Circled No. in the Form	Instruction						
(36)	Data entries with descriptions acceptable to Inspector. Abbreviations, coded identification, or reference to Code figure and sketch number may be used to define any generic name. For ASME B16.5 flanges, the class should be identified. Flange facing and attachment to neck is not required. Some typical abbreviations: <table style="margin-left: 40px; border: none;"> <tr> <td style="padding-right: 20px;">Flanged fabricated nozzle</td> <td>Cl. 300 flg</td> </tr> <tr> <td>Long weld neck flange</td> <td>Cl. 300 lwn</td> </tr> <tr> <td>Weld end fabricated nozzle</td> <td>w.e.</td> </tr> </table>	Flanged fabricated nozzle	Cl. 300 flg	Long weld neck flange	Cl. 300 lwn	Weld end fabricated nozzle	w.e.
Flanged fabricated nozzle	Cl. 300 flg						
Long weld neck flange	Cl. 300 lwn						
Weld end fabricated nozzle	w.e.						
(37)	To be completed when one or more parts of the vessel are furnished by others and certified on Data Report Form K-2 as required by KS-301. The part manufacturer's name and serial number should be indicated.						
(38)	Certificate of compliance block is to show the name of the Manufacturer as shown on Manufacturer's ASME Code Certificate of Authorization. This should be signed in accordance with organizational authority defined in the Quality Control System (see Appendix 2).						
(39)	To be completed by the Manufacturer and signed by the Authorized Inspector who performs the shop Inspection or signs Form WWPV-2 for the completed vessel. Attach any applicable K-2 forms.						
(40)	The Inspector's National Board Commission Number must be shown when the vessel is stamped "National Board." Otherwise, show only Inspector's state or province commission number.						
(41)	If additional thickness is provided as a protective or sacrificial layer beyond the thickness specified in (25), then that additional thickness shall be indicated here.						

GENERAL NOTE: Any quantity to which units of measure are needed shall be entered on the Manufacturer's Data Report with the chosen units.

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Case 2837

Use of PFA Tubing Material for Flue Gas Heat Exchanger Tubes

Section VIII, Division 1

Approval Date: September 15, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May perfluoroalkoxy (PFA) copolymer be used for flue gas heat exchanger tubes with water as the tube-side fluid and flue gas as the shell-side fluid in Section VIII, Division 1 construction? For the purpose of this Case, flue gas heat exchangers are used downstream of the boiler and electrostatic precipitator in a power plant.

Reply: It is the opinion of the Committee that PFA may be used for flue gas heat exchanger tubes in Section VIII, Division 1 construction, provided the following requirements are met.

1 GENERAL REQUIREMENTS

(a) The virgin PFA material shall have no fillers, additives, or pigments and shall be in compliance with ASTM D3307-10 and shall be limited to the polymer with a classification designation of Type II. The PFA copolymer material shall be certified by the materials manufacturer, and a certificate of analysis shall be furnished to the vessel manufacturer for each batch of finished material from a production reactor.

(1) The resin manufacturer's certificate of analysis shall include the following at a minimum with respect to ASTM D3307.

(-a) name and address of production plant where the material was made.

(-b) reactor batch number. Batch is defined as the finished capacity of the reactor producing the material during one production cycle.

(-c) certification of conformance with applicable ASTM D3307 type.

(-d) apparent bulk density.

(-e) average pellet size.

(-f) standard specific gravity of material.

(2) The tube manufacturer's certified material test report shall include the following recorded data at a minimum.

(-a) name and address of production plant where tubes were made.

(-b) lot number for each extruder run. An extruder run is the length of tubing produced by the extruder in one production cycle and is given a unique serial number, which is the lot number by the tubing manufacturer.

(-c) reference to resin manufacturer's batch number from which the tubes were made and ASTM specification, type and grade, and class.

(-d) total length of lot.

(-e) number of tubes cut from the lot coil and their nominal lengths.

(-f) design drawing number and revision showing tube dimensions.

(-g) outside diameter (O.D.) and nominal thickness of tubes.

(-h) centerline U-bend radius for each tube referenced to tube serial number.

(-i) visual inspection results per [Table 1](#) and dimensions (O.D. and wall thickness) with reference tolerances for each tube.

(-j) test pressure per [3\(c\)](#) after bending and its duration for the lot and certification of acceptable results.

(-k) manufacturer's written tubing production procedure number.

(-l) extrusion pressure range at applicable draw down ratio.

(b) The tube side of the completed heat exchanger shall be limited to liquid water service. Any service classified per UW-2(a) is not allowed.

(c) The maximum allowable design pressure for the tube side of the heat exchanger shall be limited to 110 psi (758 kPa) at a maximum temperature of 325°F (163°C).

(d) The PFA tubing shall not be subject to any differential external pressure. The exchanger shall be installed in a system that controls the operation to ensure the tube design pressure and temperature are not exceeded (e.g., maximum tube temperature exceeded due to loss of water on the tube side).

(e) The shell-side of the tubes shall not be subjected to a flue gas temperature exceeding 383°F (195°C). The design temperature of the tubes shall not be less than the maximum flue gas temperature. The minimum tube design temperature shall be no colder than 40°F (4.4°C). The design pressure of the shell side of the exchanger shall be less than 15 psig (103 kPa).

(f) The maximum nominal outside diameter of the PFA tubing shall not exceed 0.63 in. (16 mm) with a minimum wall thickness of 0.035 in. (0.89 mm). The tolerance on outside diameter shall be $\pm 1\%$, and on nominal wall thickness $+0.012$ in./-0 in. ($+0.3$ mm/-0 mm).

(g) The heat exchanger shall be limited to a vertically oriented U-tube type with the U-bends at the bottom of the exchanger, and this service restriction shall be noted in the Remarks section of the Manufacturer's Data Report.

(h) The minimum centerline radius of the U-bends shall be 4 times the outside diameter of the tubing.

(i) Repairs to the PFA tubing shall not be permitted.

(j) The PFA tubing shall be mechanically attached to a metallic tubesheet using qualified procedures and operators per 2(e) and pull-tested per 4(c).

(k) The PFA tubing shall be marked with an attached identification tag or laser etched with a unique serial number on one end that will be trimmed off during installation into the tubesheet to provide traceability to the tubing material manufacturer's report of test results as well as the raw material supplier's certificate of analysis. The tubing manufacturer shall provide a map showing the location of each marked tube into the tubesheet.

(l) The tubing shall be manufactured using melt extrusion process in which virgin PFA copolymer pellets are fed into a hopper that feeds an extruder. This process shall be controlled by a written procedure in which all of the following process variables, which are also extrusion parameters, shall be considered essential:

(1) tooling size, die and tip, in. (mm)

(2) draw down ratio (ratio of the cross sectional area of the tip and die to the cross sectional area of the tube)

(3) tooling temperature, °F (°C)

(4) tube speed, ft/min (m/min)

(5) extruder speed, rpm

(6) nominal inlet pellet size, in. (mm)

A change in any of the essential variables outside any range specified in the procedure shall require requalification of the written procedure per the test procedure specified in sections 2 and 3. The procedure shall indicate the acceptable ranges for (2) through (6) above. The tube manufacturer shall also certify that the extruder lot of tubing meets the requirements of this Case.

(m) Tubing used for qualification testing shall not be used on Code-stamped heat exchangers.

(n) The design of the tubing shall take into account published cold flow data for PFA to ensure the tubes do not permanently lengthen or expand under pressure or their own weight plus the weight of liquid and the differential longitudinal pressure stress within. To ensure cold-flow or creep is not an issue, the total longitudinal stress shall be limited to 550 psi (3.8 MPa) at the design temperature of the tube side of the exchanger. The total longitudinal stress due to pressure and weight shall be determined using the formulas in 5(b).

(o) The use of regrind or recycled material is prohibited.

(p) The completed tube-side of the heat exchanger shall be hydrostatically tested per UG-99(b) at 1.3 times the MAWP of the tube side.

NOTE: Since the tube side contains carbon steel components, the lowest stress ratio will be 1.0 at the design temperature.

(q) This Case number shall be shown on the Manufacturer's Data Report and marked on the tubing identification tag, all material test reports, and the Code nameplate.

(r) On Form U-1 line 13, the description of the tubes shall be PFA per ASTM D3307 grade to which it was manufactured listed.

2 DESIGN QUALIFICATION

The maximum allowable working pressure (which shall equal the design pressure) of the PFA tubing shall be established by the following procedure.

(a) Long term hydrostatic strength testing shall be conducted in accordance with ISO 9080:2012 or ASTM D2837-11. The testing laboratory shall be accredited by the American Association for Laboratory Accreditation (A2LA) in the USA, or shall be accredited by another agency recognized by the local jurisdiction elsewhere. The laboratory shall be qualified per ISO 17025 to perform this type of testing. The testing shall be conducted on a representative sample of a reactor batch of the virgin resin and of the extrusion lot to be used in actual production tubes using air or nitrogen as the test fluid. These tests shall be conducted at ambient, an intermediate temperature, and up to 36°F (20°C) above the design temperature for a period of 10,000 hr and use linear regression analysis to extrapolate the long-term strength for 50 yr per ISO 9080 or 100,000 hr per ASTM D2837. The long-term hydrostatic strength at the design temperature obtained shall have a design factor of 0.67 applied resulting in a design strength that does not exceed $\frac{2}{3}$ of the yield strength. The ratio of the lower confidence limit strength to the long-term hydrostatic strength shall be a minimum of 0.9 for each method.

(b) The Authorized Inspector (AI) shall verify that the certified long-term hydrostatic strength test has been completed.

(c) The design qualification tubing shall be visually examined for imperfections prior to having samples subjected to the long-term hydrostatic testing. Classification and acceptance level of imperfections shall be according to Table 1.

(d) The rules of 5(a) of this Case shall be used to calculate the hoop stress in the tube at any pressure.

(e) Mechanical designs for the tube-to-tubesheet joint must have a written joining procedure and have a tube pull-out test per 4(c). The tube-to-tubesheet joining procedure shall include procedure specifications, performance qualifications, acceptance criteria, and a procedure

for how workers joining tubes to tubesheets shall be qualified. The procedure shall be acceptable to the AI and the user.

3 PRODUCTION TUBES

(a) Each tubing extruder run or lot shall be examined by the tube manufacturer externally over its entire length for imperfections. Classification and acceptance level of imperfections shall be according to Table 1. Any defective area found larger than the maximum allowable size shall be removed in its entirety.

(b) All tubes in a production extruder lot shall be examined for conformance with dimensions and tolerances shown on the design drawings or given in ASTM D6867, whichever is more restrictive. Any dimension falling outside the specified limit or the tolerances of this Case shall require the defective section to be rejected, cut out, and not used.

(c) After the tube manufacturer bends the tubes, they shall be subjected to a minimum hydrostatic pressure test of 70% of the burst pressure at the tube manufacturer with water at 70°F ±5°F (21°C ±3°C) for a minimum hold time of 15 min. Any failure due to burst, visible deformation, or leakage shall reject that specific tube. Retesting is not permitted.

4 PRODUCTION QUALIFICATION

(a) At least one tube per 65,000 ft (20,000 m) or at least one tube per bundle, whichever is less, shall be subject to cold and hot burst tests by the exchanger manufacturer in accordance with the following procedures. These tests shall be witnessed by the AI and certified by the manufacturer.

(1) Cold Burst Pressure Test

(-a) Cut five 10-in. ± $\frac{1}{16}$ in. (250-mm ±2 mm) long samples from the test tube.

(-b) Condition the tubes for at least 4 hr at 73°F ±5°F (23°C ±2.8°C) prior to testing. The test fluid temperature shall also be at this temperature.

(-c) Measure the wall thickness and outer diameter, and record these values on the manufacturer's quality control form.

(-d) Close one end of the tube with a compression plug fitting, and install a fill fitting on the other end. Fill the samples with mineral oil or water, and plug the fill fitting. Make sure no visible air bubbles are present in the tube.

(-e) Raise the pressure of the fluid at a maximum rate of 145 psi/min (1 MPa/min) to 203 psig (1.4 MPa), and hold for a minimum of 6 min.

(-f) Then raise the pressure at a maximum rate of 29 psi/min (200 kPa/min) until the tube bursts. If the end plug leaks or fails before the tube bursts or leaks, the test is not valid.

(-g) Record the burst pressure at the end of the test as well as all test conditions.

(-h) The burst hoop stress shall have a minimum value of 1,500 psi (10.3 MPa) for any of the samples that shall be calculated per 5(a).

(2) Hot Burst Pressure Test

(-a) Cut five 6-in. ± $\frac{1}{16}$ in. (150-mm ±2 mm) long samples from the test tube.

(-b) Measure the wall thickness and outer diameter, and record these values on the manufacturer's quality control form.

(-c) Close one end of the tube with a compression plug fitting.

(-d) Fill each tube to 75% of its volume with water (the rest is air) at a minimum temperature of 60°F (15°C).

(-e) Close the open end of the tube with a plug fitting.

(-f) Install oven thermocouples onto the tubes.

(-g) Heat the tubes in an oven preheated at 320°F ±4°F (160°C ±2°C) in a way that they are visible once the door is closed.

(-h) Condition the tubes for 15 min at the preheated temperature.

(-i) Raise the temperature at a maximum rate of 5.4°F/min (3°C/min) until all tubes burst or leak. If the end plug leaks or fails before the tube bursts or leaks, the test is not valid.

(-j) Record the temperature during the whole test including rate of temperature rise.

(-k) Note the burst or leak temperature of each tube, and record it on the certified test report.

(-l) The steam pressure at burst can be calculated using the steam pressure table of water.

(-m) The burst hoop stress shall be calculated per 5(a) and have a minimum value of 583 psi (4.02 MPa) for any of the samples.

(b) The tubing to be used for these tests shall be selected at random by the Authorized Inspector, and the test results shall be certified by the manufacturer on their material test report.

(c) In addition to meeting the procedure performance qualifications of 2(e) for tube-to-tubesheet joints, and before making production tube-to-tubesheet joints, each worker shall demonstrate to the satisfaction of the AI the ability to achieve complete tube-to-tubesheet joints by successfully assembling six test pieces with a minimum joint pull-out strength that exceeds the strength of the bare tube. The test pieces shall be visually examined to verify a complete joint, sectioned to verify minimum required tube thickness and complete compression of the tube along the entire length of the joint. For each worker's mock-up assembly, a tube pull-out test shall be done for each size and thickness of tube being used using six tubes in a tubesheet mock-up. The tube pull-out test shall establish that the tubes will fail outside the tubesheet before the tube-to-tubesheet joint fails. The results shall be recorded and maintained with the performance qualification record. The results for each

worker shall be acceptable to the AI before that worker performs any production tube-to-tubesheet joints.

5 TUBE-STRESS CALCULATIONS

(a) The hoop stress in the tubing at any pressure [see 2(d), 4(a)(1)(-h), and 4(a)(2)(-m)] shall be calculated based on the following equation for internal pressure.

$$S_h = Pr/t$$

where

- P = internal pressure
- r = maximum inside radius of the tube
- S_h = hoop stress value at a pressure, P
- t = minimum thickness of the tube

(b) The longitudinal stress in the tubing at pressure, P [see 1(n)] and total longitudinal stress shall be calculated based on the following equations:

$$S_{lp} = Pr/2t$$

$$S_l = S_{lp} + W/A$$

where

- A = cross sectional area of the tubing

S_l = total longitudinal stress due to pressure and weight

S_{lp} = longitudinal stress value at pressure, P

W = weight of suspended tubing below the tubesheet plus the weight of the water contained in the suspended tube

P , r , and t are defined in (a).

6 PHYSICAL PROPERTIES

Select physical properties for PFA to be used for design are as follows:

(a) Thermal Conductivity =

0.14 Btu/hr-ft-°F (0.25 W/m-K)

(b) Linear Coefficient of Expansion

(1) 70°F to 212°F (21°C to 100°C) =
 7.8×10^{-5} in./in. °F (14×10^{-5} mm/mm °C)

(2) 212°F to 300°F (100°C to 149°C) =
 9.8×10^{-5} in./in.°F (18×10^{-5} mm/mm °C)

(3) 300°F to 408°F (149°C to 208°C) =
 12.1×10^{-5} in./in. °F (22×10^{-5} mm/mm °C).

7 SUMMARY OF CODE CASE REQUIREMENTS

Table 2 provides a summary and location of the Case requirements for material, design, and qualification.

Table 1
Visual Flaw Acceptance Criteria

Defect	Definition	Maximum Size, in. (mm)
Black spots, brown streaks	Dark spots or streaks	0.015 (0.4)
Blisters	Hollows on or in the part	0.015 (0.4)
Bubbles	Air entrapped in the part	0.015 (0.4)
Burn marks, dieseling	Charred or dark plastic caused by trapped gas	0.015 (0.4)
Cracking, crazing	Any visible	0.015 (0.4)
Delamination	Single surface layers that flake off the part	0.015 (0.4)
Discoloration	Similar to burn marks but generally not as dark or severe	Acceptable
Flow, halo, blush marks	Marks seen on the part due to flow of molten plastic across the molding surface	0.015 (0.4)
Gels	Bubbles or blisters on or in the part due to poor melt quality	0.015 (0.4)
Jetting	Undeveloped frontal flow	0.015 (0.4)

Table 2
Summary of Material, Design, and Qualification Requirements

Requirement	Paragraph	Comment
Material specification	1(a)	Resin raw material
Minimum wall thickness	1(f)	...
Maximum OD	1(f)	...
Extrusion process and procedure qualification	1(l)	Qualified procedure required
Tube side design pressure (internal and external)	1(c) and 1(d)	...
Tube side temperature	1(c)	...
Maximum shell side design pressure	1(e)	...
Maximum design temperature of shell side	1(e)	...
Maximum design temperature of tubes	1(e)	...
Tube configuration and orientation	1(g)	Vertical U-tube only
Maximum longitudinal tube stress	1(n)	...
Minimum bend radius	1(h)	...
Tube-to-tubesheet joint	1(j), 2(e), and 4(c)	...
Tube side hydrostatic test pressure	1(p)	...
Design pressure qualification	2(a)	Long-term hydrostatic tests
Production qualifications	4(a) and 4(c)	Cold and hot burst tests and pull-out tests
Tube stress calculation formulas	5(a) and 5(b)	Hoop and longitudinal stress
Material physical properties	6(a) and 6(b)	...

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Case 2838

NDE Personnel Qualification and Certification Requirements

Section IX

Approval Date: September 15, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may NDE personnel qualification and certification be performed under the provisions of ISO 9712 or other national or international standards in lieu of the provisions of QW-191.2.2?

Reply: It is the opinion of the Committee that NDE personnel qualification and certification may be performed under the provisions of ISO 9712 or other national or

international standards in lieu of the provisions of QW-191.2.2, provided the following requirements are met:

(a) The applicable requirements of Section V, Article 1, T-120 shall be met.

(b) When NDE has been performed by personnel whose qualification and certification has been completed by an employer under the provisions of this Case, this Case number shall be shown on the affected welder performance qualification record.

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Case 2839-2

9Cr-3W-3Co-Nd-B Material

Section I

Approval Date: May 4, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May normalized and tempered 9Cr-3W-3Co-Nd-B seamless tubes, pipes, and forgings conforming to the chemical analysis shown in [Table 1](#), the minimum mechanical properties listed in [Table 2](#), and otherwise conforming to the specifications listed in [Table 3](#) be used for Section I construction?

Reply: It is the opinion of the Committee that normalized and tempered 9Cr-3W-3Co-Nd-B seamless tubes, pipes, and forgings conforming to the chemical analysis shown in [Table 1](#), the minimum mechanical properties listed in [Table 2](#), and otherwise conforming to the specifications listed in [Table 3](#) may be used for Section I construction, provided the following requirements are met:

(a) The material shall be normalized at 1,960°F to 2,140°F (1 070°C to 1 170°C) and tempered at 1,380°F to 1,455°F (750°C to 790°C) as final heat treatment.

(b) The material shall not exceed a Brinell Hardness Number of 250 HBW (HRC 25).

(c) The maximum design temperature shall be 1,200°F (649°C).

(d) The maximum allowable stress values for the material shall be those given in [Tables 4](#) and [4M](#).

(e) Separate weld procedure qualifications conducted in accordance with Section IX shall be required for this material. For the purpose of performance qualification, the material shall be considered P-No. 15E, Group 1.

(f) Postweld heat treatment for this material is mandatory, and the following rules shall apply:

(1) The time requirement shall be those given for P-No. 15E, Group 1 materials in [Table PW-39](#).

(2) The PWHT temperature range shall be 1,350°F to 1,455°F (730°C to 790°C).

(3) Exemptions to postweld heat treatment for this material shall be in accordance with the rules for P-No. 15E, Group 1 materials in [Table PW-39-5](#).

(g) All cold-formed material shall be heat treated as follows:

(1) Cold-forming is defined as any forming that is performed at a temperature below 1,300°F (705°C) and produces permanent strain in the material.

(2) The forming strains shall be calculated using the equations of PG-19. When the forming strains cannot be calculated as shown in PG-19, the Manufacturer shall have the responsibility to determine the maximum forming strain, except as limited by (3) and (8).

(3) For cold-formed flares, swages, or upsets in tubing or pipe, the material shall be normalized and tempered in accordance with (8).

(4) For design temperatures exceeding 1,000°F (540°C) but less than or equal to 1,115°F (600°C), and cold-forming strains greater than 25%, the material shall be normalized and tempered in accordance with (8).

(5) For design temperatures exceeding 1,115°F (600°C) and cold-forming strains greater than 20%, the material shall be normalized and tempered in accordance with (8).

(6) For design temperatures exceeding 1,000°F (540°C) but less than or equal to 1,115°F (600°C), and cold-forming strains greater than 5% but less than or equal to 25%, the material shall be heat treated in accordance with (9), (10), or (11).

(7) For design temperatures exceeding 1,115°F (600°C) and cold-forming strains greater than 5% but less than or equal to 20%, the material shall be heat treated in accordance with (10) or (11).

(8) Normalization and tempering shall be performed in accordance with the requirements of (a) and shall not be performed locally. The material shall either be heat treated in its entirety, or the cold-strained area (including the transition to the undeformed portion) shall be cut away from the balance of the component and heat treated separately, or replaced.

(9) Post-cold-forming heat treatment shall be performed at 1,350°F to 1,425°F (730°C to 775°C) for 1 hr/in. (1 h/25 mm) or 30 min minimum. Alternatively, the material may be normalized and tempered in accordance with (8).

(10) For design temperatures less than or equal to 1,115°F (600°C) and cold-forming strains greater than 5% but less than or equal to 25%, if a portion of the component is heated above the post-forming heat treatment, then the component shall be normalized and tempered according to (8).

(11) If a longitudinal weld is made to a portion of the material that is cold-strained, that portion shall be normalized and tempered in accordance with (8).

(12) In all other cases, heat treatment is neither required nor prohibited.

(h) All material formed at or above 1,300°F (705°C) shall be renormalized and tempered in accordance with (a). This heat treatment shall not be performed locally. The material shall be either heat treated in its entirety, or the hot-formed area (including the transition) shall be cut away from the balance of the tube or component and heat treated separately or replaced.

(i) Except as provided in (j), if during manufacturing any portion of the component is heated to a temperature greater than 1,455°F (790°C), then the component heated above 1,455°F (790°C) including the heat-affected zone created by the local heating shall be removed, renormalized, and tempered, and then replaced in the component.

(j) If the allowable stresses to be used are less than or equal to those provided in Section II, Part D, Subpart 1, Table 1A for Grade 9 (SA-213 T9) at the design temperature, then the requirements of (i) may be waived, provided that the portion of the component heated to a temperature greater than 1,455°F (790°C) is reheat treated within the temperature range 1,350°F to 1,425°F (730°C to 775°C).

(k) The yield strength and tensile strength values for use in design shall be as given in Tables 5 and 5M.

(l) The physical properties for the 9Cr-3W-3Co-Nd-B material are as follows:

(1) mean linear thermal expansion coefficients, as given in Tables 6 and 6M

(2) thermal conductivity, as given in Tables 6 and 6M

(3) density: 0.285 lb/in.³ (7900 kg/m³)

(4) modulus of elasticity, as given in Tables 6 and 6M

(5) Poisson's ratio: 0.29

(m) External pressure design is prohibited.

(n) This Case number shall be referenced in the documentation and marking of the material and shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition Limits, %
Carbon	0.05–0.10
Manganese	0.20–0.70
Phosphorus, max.	0.020
Sulfur, max.	0.008
Silicon	0.05–0.50
Chromium	8.50–9.50
Tungsten	2.5–3.5
Cobalt	2.5–3.5
Nickel, max.	0.20
Vanadium	0.15–0.30
Columbium + Tantalum	0.05–0.12
Neodymium	0.010–0.060
Boron	0.007–0.015
Aluminum, max.	0.030
Nitrogen	0.005–0.015
Oxygen, max.	0.0050

Table 2
Mechanical Property Requirements

Tensile strength, min., ksi (MPa)	90 (620)
Yield strength, min., ksi (MPa)	64 (440)
Elongation in 2 in., min. %	19
[Note (1)]	

NOTE:

(1) For longitudinal strip tests, a deduction from the basic values of 1.00% for each $\frac{1}{32}$ in. (0.8 mm) decrease in wall thickness below $\frac{5}{16}$ in. (7.8 mm) shall be made. The following table gives the computed values.

Wall Thickness, in.	Elongation in 2 in., Min. %
$\frac{5}{16}$ (0.312)	19.0
$\frac{9}{32}$ (0.281)	18.0
$\frac{1}{4}$ (0.250)	17.0
$\frac{7}{32}$ (0.219)	16.0
$\frac{3}{16}$ (0.188)	15.0
$\frac{5}{32}$ (0.156)	14.0
$\frac{1}{8}$ (0.125)	13.0
$\frac{3}{32}$ (0.094)	12.0
$\frac{1}{16}$ (0.062)	11.6
0.062 to 0.035, excl.	10.9
0.035 to 0.022, excl.	10.6
0.022 to 0.015, incl.	10.3

GENERAL NOTE: The above table gives the computed minimum elongation values for each $\frac{1}{32}$ in. decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value shall be determined by the following equation:

$$E = 32t + 10.0$$

where

E = elongation in 2 in., %

t = actual thickness of specimen

Table 3
Specifications

Material	Specification
Forgings	SA-182/SA-182M
Pipe	SA-335/SA-335M
Tube	SA-213/SA-213M

Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi
-20 to 100	25.7
200	25.7
300	25.1
400	24.3
500	23.8
600	23.3
650	23.0
700	22.7
750	22.2
800	21.7
850	21.0
900	20.2
950	19.2
1,000	18.1
1,050	16.9
1,100	15.5
1,150	12.0 [Note (1)]
1,200	6.5 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

Table 4M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress, MPa
-30 to 40	177
100	177
200	168
300	162
400	153
425	150
450	146
475	141
500	135
525	129
550	121
575	113
600	103 [Note (1)]
625	79 [Note (1)]
650	44 [Note (1)] , [Note (2)]

NOTES:

(1) These values are obtained from time-dependent properties.

(2) The maximum use temperature shall be 649°C. Datum for 650°C temperature is provided for interpolation purposes.

**Table 5
Yield and Tensile Strength Values**

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (1)]
-20 to 40	64.0	90.0
100	62.5	88.2
200	59.1	83.5
300	57.0	79.9
400	56.0	77.5
500	55.5	75.7
600	55.1	74.1
650	54.8	73.2
700	54.3	72.1
750	53.5	70.7
800	52.4	68.9
850	50.9	66.8
900	49.0	64.3
950	46.6	61.2
1,000	43.7	57.7
1,050	40.4	53.8
1,100	36.5	49.4
1,150	32.1	44.7
1,200	27.3	39.7

NOTE: (1) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

**Table 5M
Yield and Tensile Strength Values**

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (1)]
-30 to 20	440	620
40	430	620
65	418	591
100	405	572
150	393	551
200	386	535
250	383	524
300	381	514
325	380	509
350	377	503
375	374	496
400	369	487
425	362	476
450	353	463
475	341	448
500	328	430
525	311	409
550	292	386
575	270	361
600	245	333
625	217	303
650 [Note (2)]	187	272

NOTES:

- (1) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The maximum use temperature shall be 649°C. Datum for 650°C temperature is provided for interpolation purposes.

Table 6
Physical Properties

Temperature, °F	Modulus of Elasticity, 10 ³ ksi	Thermal Conductivity, Btu/ft-hr-°F	Mean CTE, 10 ⁻⁶ in./in./°F [Note (1)]	Specific Heat, Btu/lb-°F
68	31.6	13.0	...	0.102
200	31.2	13.6	5.8	0.109
400	30.4	14.3	5.9	0.117
600	29.3	14.7	6.1	0.127
800	27.7	15.0	6.4	0.139
1,000	25.7	15.1	6.6	0.157
1,150	24.4	15.2	6.7	0.169
1,200	22.7	15.3	6.8	0.183

NOTE: (1) Mean CTE values are those from 68°F to indicated temperature.

Table 6M
Physical Properties

Temperature, °C	Modulus of Elasticity, GPa	Thermal Conductivity, W(m ⁻¹ /K ⁻¹)	Mean CTE, 10 ⁻⁶ °C ⁻¹ [Note (1)]	Specific Heat, kJ kg ⁻¹ °C ⁻¹
20	218	22.5	...	0.434
100	215	23.3	10.4	0.446
200	210	24.7	10.6	0.491
300	203	25.5	11.0	0.530
400	194	25.8	11.4	0.572
500	182	26.2	11.7	0.630
600	167	26.1	12.1	0.705
700	143	26.6	12.4	0.831

NOTE: (1) Mean CTE values are those from 20°C to indicated temperature.

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Case 2840-1

29Cr-6.5Ni-2Mo-N Austenitic-Ferritic Stainless Steel, UNS S32906 Hot Isostatically-Pressed Material (Class 2)

Section VIII, Division 1; Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed alloy UNS S32906 hot isostatically-pressed flanges, fittings, valves, and parts with chemical compositions conforming to [Table 1](#), mechanical properties conforming to [Table 2](#), and otherwise conforming to the respective requirements of ASTM A988/A988M-15 be used in welded construction under the rules of Section VIII, Division 1 or Division 2, Class 2?

Reply: It is the opinion of the Committee that solution annealed UNS S32906 material for hot isostatically-pressed alloy steel powder metallurgy parts as described in the Inquiry may be used in welded construction under the rules of Section VIII, Division 1 or Division 2, Class 2, provided that the following additional requirements are met:

- (a) The maximum use temperature is 600°F (316°F).
- (b) The material shall be heat treated to a temperature of 1,850°F to 2,100°F (1010°C to 1150°C) followed by rapid cooling in air or water.
- (c) Welding procedures and performance qualifications shall be conducted in accordance with Section IX. This material shall be considered P-No. 10H, Group 1.
- (d) For external pressure design, Section II, Part D, Subpart 2, Figure HA-5 and Table HA-5 shall apply.
- (e) The maximum allowable stress values for UNS S32906 shall be those given in Section II, Part D, Subpart 1, Table 1A for thicknesses of 0.40 in. (10 mm) and greater for Division 1 construction, and Section II, Part D, Subpart 1, Table 5A for thicknesses of 0.40 in. (10 mm) and greater for Division 2, Class 2 construction.
- (f) The maximum allowable powder size is 0.019 in. (0.5 mm), and the powder shall be produced by the gas atomization process.
- (g) In addition to a chemical composition analysis of the final blend powder, a chemical analysis of a sample (component or compact) from each lot of parts shall be required and conform to the requirements of [Table 1](#).

(h) For use in design, the tensile strength values for thicknesses of 0.40 in. (10 mm) and greater shall be applied from Section II, Part D, Subpart 1, Table U.

(i) For use in design, the yield strength values for thicknesses of 0.40 in. (10 mm) and greater shall be applied from Section II, Part D, Subpart 1, Table Y-1.

(j) The physical properties from Section II, Part D for UNS S32906 (29Cr-6.5Ni-2Mo-N) shall apply.

(k) For Division 2, Class 2 fatigue analysis, this material shall be considered Table 3-F.3 material.

(l) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UHA for austenitic-ferritic duplex stainless steels. For Section VIII, Division 2, Class 2 application, the rules for austenitic-ferritic duplex stainless steels shall apply.

(m) This Case number shall be shown on the marking and certification of the material and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition Limit, %
Carbon	0.030 max.
Manganese	0.80–1.50
Phosphorous	0.030 max.
Sulfur	0.030 max.
Silicon	0.50 max.
Chromium	28.0–30.0
Nickel	5.8–7.5
Molybdenum	1.50–2.60
Copper	0.80 max.
Nitrogen	0.30–0.40

Table 2
Mechanical Test Requirements (Room Temperature)

Minimum Tensile Strength, ksi (MPa)	Minimum Yield Strength, 0.2% Offset, ksi (MPa)	Minimum Elongation in 2 in. (50 mm) %
109 (750)	80 (550)	25

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Case 2841

Alternative Rules for Access in Firetube Boilers

Section I

Approval Date: February 17, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the minimum clearance of 12 in. (300 mm) between the underside of the wet-bottom and the floor in PFT-46.6 be reduced to minimum clearance of 6 in. (150 mm)?

Reply: It is the opinion of the Committee that minimum clearance between the underside of the wet-bottom and the floor may be reduced to a minimum clearance of 6 in. (150 mm), provided the following requirements are met:

(a) The boiler is a horizontal firetube boiler with a shell radius of 20 in. (500 mm) or less.

(b) Inspection openings are provided on both sides of the boiler at an angle no less than 30 deg and no greater than 45 deg from the bottom of the shell at locations along the length of the boiler to facilitate inspection of the wet bottom.

(c) The boiler is equipped with washout plugs at the bottom to facilitate flushing of the boiler in accordance with PFT-43.

(d) This Case number shall be shown on the Master Data Report.

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Case 2843-3

Analysis of Class 2 Components in the Time-Dependent Regime

Section VIII, Division 2

Approval Date: June 27, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May Section VIII, Division 2, Class 2 components operating in the time-dependent regime and constructed of annealed 2.25Cr-1Mo steel, 9Cr-1Mo-V steel (Grade 91), type 304 and 316 stainless steel, and nickel alloy 800H materials be analyzed by the strain deformation method?

Reply: It is the opinion of the Committee that Section VIII, Division 2, Class 2 components operating in the time-dependent regime and constructed of annealed 2.25Cr-1Mo steel, 9Cr-1Mo-V steel (Grade 91), type 304 and 316 stainless steel, and nickel alloy 800H materials may be analyzed by the strain deformation method as follows.

1 SCOPE

The design rules of this method are only applicable to the materials listed in [Table 1](#) and the temperature range and maximum service life listed in [Table 2](#).

Bolting is not included in the scope of this Case.

2 STRAIN DEFORMATION METHOD

The general outline for this procedure is shown in [Figure 1](#).

3 MATERIALS AND OTHER PROPERTIES

3.1 MATERIALS

Materials that may be used at elevated temperatures in this Case are presently limited to those in [Table 1](#).

3.2 WELD MATERIALS

Weld materials that may be used at elevated temperatures in this Case are presently limited to those in [Table 3](#).

3.3 DESIGN FATIGUE STRAIN RANGE

The fatigue data for the materials listed in [Table 1](#) are shown in Section II, Part D, Nonmandatory Appendix E, Figures E-100.16-1 through E-100.16-5.

3.4 STRESS VALUES

The stress designations in [Table 4](#) are defined in [3.5](#) and their numerical values listed in Section II, Part D, Nonmandatory Appendix E.

The allowable shear stress used in this Case is the same as that used in Section VIII, Division 2, Part 5 with the exception of substituting S_{mt} for S . The allowable bearing stress shall be the smaller of

(a) yield stress at operating temperature.

(b) the stress at 0.2% offset strain as obtained from the isochronous stress-strain curve for the operating temperature and for the time duration equal to the total life.

3.5 STRESS TERMS

The terms shown in [8](#), the nomenclature of this Code Case, in addition to the nomenclature in Part 5 of Section VIII, Division 2, are applicable to this Case.

4 DESIGN CRITERIA

Evaluation of components in the creep regime consists of satisfying load controlled limits, strain controlled limits, and creep-fatigue consideration. Satisfying load controlled limits assures maintaining stress levels below code allowable values. Satisfying strain controlled limits assures against failure due to ratcheting. Satisfying creep-fatigue criterion establishes the expected life of the components.

4.1 SHORT-TERM LOADS

The tensile stress values, S_u , and the yield stress values, S_y , used in this Case when operating in the time-dependent regime may need to be reduced due to material deterioration when the applied loads are short term such as wind and seismic loads. [Table 5](#) lists reduction factor C_1 for various materials and temperatures.

When the yield and ultimate tensile strengths are reduced by the operating elevated temperature, it is necessary to appropriately reduce the values of S_{mt} and S_m . The reduced values shall be taken as the smallest of

(a) the S_{mt} and S_m values taken from Section II, Part D, Figures E-100.4-1 through E-100.4-5

(b) the product of $\frac{1}{3}$ of the tensile strength at temperature (Section II, Part D, Tables E-100.1-1 and E-100.1-2) and the tensile strength reduction factor C_1 (Table 5)

(c) the product of $\frac{2}{3}$ of the yield stress at temperature (Section II, Part D, Table E-100.6-1) and the yield stress reduction factor C_1 (Table 5)

5 LOAD-CONTROLLED LIMITS

Load controlled limits shall be satisfied for both design and operating conditions. The criterion is outlined in Figure 2.

5.1 DESIGN LOAD LIMITS

The stress calculations required for the analysis of design loadings shall be based on a linearly elastic material model. The calculated equivalent stress values shall satisfy the limits of (a) and (b).

(a) The general primary membrane equivalent stress derived from P_m shall not exceed S :

$$P_m \leq S \quad (1)$$

The value of S is determined at the design temperature.

(b) The combined local primary membrane plus primary bending equivalent stresses derived from P_L and P_b shall not exceed 1.5 S :

$$P_L + P_b \leq 1.5S \quad (2)$$

5.2 OPERATING LOAD LIMITS

The stress calculations required for the analysis of operating loadings shall be based on a linearly elastic material model. The calculated equivalent stress values shall satisfy the limits of (a) through (e).

(a) The general primary membrane equivalent stress derived from P_m shall not exceed S_{mt} :

$$P_m \leq S_{mt} \quad (3)$$

The value of S_{mt} is determined at the maximum wall averaged temperature that occurs during the particular loading event.

(b) The combined local primary membrane plus primary bending equivalent stresses derived from P_L and P_b shall satisfy the following limits:

$$(P_L + P_b) \leq KS_m \quad (4)$$

$$(P_L + P_b/K_t) \leq S_t \quad (5)$$

The values of S_m and S_t are determined at the maximum wall averaged temperature that occurs during the particular loading event.

(c) In eq. (5), the S_t value is determined for the time, t , corresponding to the total duration of the combined equivalent stress derived from P_L and P_b/K_t .

(d) When time, t , in (a) and (b), is less than the total specified service life of the component, the cumulative effect of all the loadings shall be evaluated by the following use-fraction sum equation. In addition, it is permissible and often advantageous to subdivide loading history into several load levels and into several temperatures at any given load level.

$$\sum_i \left(\frac{t_i}{t_{im}} \right) \leq 1.0 \quad (6)$$

The use of Section II, Part D, Figures E-100.5-1 through E-100.5-5 for determining t_{im} for two loading conditions at two different temperatures is shown schematically in Figure 3. In this figure, P_{mi} ($i = 1, 2, 3$, etc.) represents the calculated membrane equivalent stress for the loading condition and temperature in question; and T_i represents the maximum local wall averaged temperature during t_i . Note that it may be desirable to consider that a given equivalent stress, P_{mi} acts during several time periods, t_i , to take credit for the fact that the temperature varies with time.

(e) When time, t , in (b) is less than the total service life of the component, the cumulative effect of all [$P_L + (P_b/K_t)$] loadings shall be evaluated by the following use-fraction sum equation. The use of Section II, Part D, Figure E-100.15-3 and Figures E-100.16-1 through E-100.16-5 for determining t_{ib} for two loading conditions at two different temperatures is shown schematically in Figure 4. It is permissible and often advantageous to separate a loading history into several load levels and into several temperatures at any given load level.

$$\sum_i \left(\frac{t_i}{t_{ib}} \right) \leq 1.0 \quad (7)$$

6 STRAIN LIMITS

The requirement of strain limits are summarized in Figure 5. Where creep effects are presumed significant, inelastic analysis is generally required to provide a quantitative assessment of deformations and strains. However, elastic analysis or simplified inelastic analysis may be justified and used to establish conservative bounds for deformations, strains, strain ranges, and maximum stress to reduce the number of locations in a structure requiring detailed inelastic analysis.

6.1 TEST A-1 ALTERNATIVE RULES IF CREEP EFFECTS ARE NEGLIGIBLE

Test A-1 is a screening criterion for determining whether or not creep is negligible. Compliance with this test indicates that creep is not an issue, and the rules in Section VIII, Division 2, Part 5 may be used directly at the elevated temperature.

To comply with this test, the requirements of (a), (b), and (c) shall be met.

(a) Equation (8) as follows:

$$\sum_i \left(\frac{t_i}{r t_{id}} \right) \leq 0.1 \quad (8)$$

(b) Equation (9) as follows:

$$\sum \varepsilon_i \leq 0.2\% \quad (9)$$

If (a) and (b) are satisfied, then the requirements of Section VIII, Division 2, 5.5.6 may be applied in accordance with (c) and (d).

(c) The combined equivalent $(P_L + P_b + Q)$ stresses (see Figure 6) shall satisfy the following:

$$(P_L + P_b + Q) \leq \text{lesser of } (3S_m \text{ or } 3\bar{S}_m) \quad (10)$$

The value of S_m is determined at the maximum wall temperature at the high end of the cycle. The value of $3\bar{S}_m$ is determined from the following:

(1) when part of the cycle falls below the creep temperature given in Table 7

$$3\bar{S}_m = 1.5S_{mL} + 0.5S_{tH}$$

(2) when both temperature extremes of the cycle are above the temperature shown in Table 7

$$3\bar{S}_m = 0.5S_{tL} + 0.5S_{tH}$$

where

S_{mL} = the value of S_m determined at the maximum wall temperature at the low end of the cycle

S_{tH} = the value of S_t at the maximum wall temperature at the hot end of the cycle

S_{tL} = the value of S_t at the maximum wall temperature at the low end of the cycle

$0.5S_{tH}$ = an approximate conservative value for the relaxation stress, S_{rH} , at the hot end of the cycle

$0.5S_{tL}$ = an approximate conservative value for the relaxation stress, S_{rL} , at the cold end of the cycle

The quantity $3\bar{S}_m$ is a creep shakedown criterion. The $1.5S_m$ value represents the yield strength and the $0.5S_t$ value represents a conservative approximation of the hot relaxation stress S_{rH} .

(d) Thermal stress ratcheting shall be kept below a certain limit defined by the following equations:

(1) for linear thermal distribution

(-a) for $0 < x < 0.5$

$$y' = \frac{1}{x} \quad (11)$$

(-b) for $0.5 < x < 1.0$

$$y' = 4(1 - x) \quad (12)$$

(2) for parabolic thermal distribution

(-a) for $0.3 < x < 0.615$

$$y' = 10.3855e^{-2.6785x} \quad (13)$$

(-b) for $0.615 < x < 1.0$

$$y' = 5.2(1 - x) \quad (14)$$

6.2 STRAIN LIMITS — ELASTIC ANALYSIS

6.2.1 General Requirements. Satisfying the strain limits, described herein as Tests A-2 and A-3, is mandatory for creep-fatigue analysis. Figure 7 shows a flow diagram for Tests A-2 and A-3. Only one of these two tests shall be satisfied to comply with the strain limits requirement for elastic analysis. Test A-2 is applicable to all operating temperatures while Test A-3 is applicable for those cycles during which the average wall temperature at one of the stress extremes defining the maximum secondary stress range Q_{\max} is below the applicable temperature of Table 8.

The following definitions apply to Tests A-2 and A-3.

$$X = \frac{(P_L + P_b/K_t)_{\max}}{S_{ya}} \quad (15)$$

$$Y = \frac{Q_{\text{range}}}{S_{ya}} \quad (16)$$

where

$(P_L + P_b/K_t)_{\max}$ = the maximum value of the local primary equivalent stress, adjusted for bending via K_t during the cycle being considered

Q_{range} = the maximum value of the secondary equivalent stress range during the cycle being considered

S_{ya} = the average of the S_y values at the maximum and minimum wall averaged temperatures during the cycle being considered

6.2.2 Test A-2. This test is applicable to all operating temperatures. For this test, the following requirement shall be met:

$$\left(X + Y \right) \leq \frac{S_a}{S_{ya}} \quad (17)$$

where S_a is the lesser of

(a) $1.25S_t$ using the highest wall averaged temperature during the cycle and a time value of 10^4 hr

(b) the average of the two S_y values associated with the maximum and minimum wall averaged temperatures during the cycle

6.2.3 Test A-3. This test is applicable for those cycles during which the average wall temperature at one of the stress extremes defining the maximum secondary stress range Q_{\max} is below the applicable temperature of Table 8. For this test the following requirement shall be met:

$$X + Y \leq 1 \quad (18)$$

6.3 STRAIN LIMITS — SIMPLIFIED INELASTIC ANALYSIS

6.3.1 General Requirements. The requirements of Tests B-1 and B-2 are intended to keep the stresses in components below ratcheting levels.

6.3.2 General Requirements for Tests B-1 and B-2.

(a) The strain limits of 6.4 are considered to have been satisfied if the limits of Tests B-1 or B-2 in 6.3.3 are satisfied in addition to the following:

(1) Tests B-1 and B-2 are applicable when the average wall temperature at one of the stress extremes defining each secondary equivalent stress range Q is below the applicable temperature of Table 7.

(2) The quantity X_1 in Figures 8 and 9 is given by

$$X_1 = \frac{(P_{1L} + P_{1b}/K_t)_{\max}}{S_{yL}} \quad (19)$$

(3) The quantity Y_1 in Figures 8 and 9 is given by

$$Y_1 = \frac{Q_1}{S_{yL}} \quad (20)$$

(4) The quantities X_1 and Y_1 used in Tests B-1 and B-2 are calculated using S_{yL} in lieu of S_y .

(5) The value of effective creep stress parameter, Z , is obtained from Figure 8 or 9 as described in 6.3.3.

(6) The effective creep stress σ_c is determined from the following equation.

$$\sigma_c = Z \times S_{yL} \quad (21)$$

(7) The creep ratcheting strain, ϵ_{cr} , is determined by multiplying σ_c by 1.25 and entering the isochronous stress-strain chart at the designated temperature and time with a value of $1.25\sigma_c$ to obtain the creep ratcheting strain. The 1.25 factor is used to increase the tabulated minimum values of S_{yL} in eq. (21) when entering the isochronous curves, which are based on average values.

(8) The elastic strain, ϵ_e , is determined from the equation

$$\epsilon_e = \frac{1.25\sigma_c}{E} \quad (22)$$

The value of E is determined from an isochronous stress-strain curve at the maximum wall averaged temperature.

(9) The inelastic creep strain, ϵ_i , is calculated from the equation $\epsilon_i = \epsilon_{cr} - \epsilon_e$

(10) The inelastic creep strain ϵ_i , is limited to 1% for parent metal and $1/2\%$ for weld metal.

(b) The following procedural requirements are used in complying with (a)(1) through (a)(10).

(1) The individual cycle as defined in the design specification cannot be split into subcycles.

(2) The time used to enter the isochronous curves for individual cycles or time blocks shall always sum to the entire life regardless of whether all or only part of the cycles are evaluated under these procedures.

(3) The total service life may be subdivided into temperature-time blocks. The value of σ_c may differ from one block to another, but remains constant throughout each block service time. When σ_c is reduced at the end of a block of loading, the time of the block of loading must be longer or equal to the time needed for σ_c to relax at constant total strain to the σ_c value for the subsequent block. The creep strain increment for each block may be evaluated separately. The times used in selecting the isochronous curves can be entered at the initial strain accumulated throughout the prior load history. The creep strain increments for each time-temperature block shall be added to obtain the total ratcheting creep strain.

6.3.3 Applicability of Tests B-1 and B-2.

6.3.3.1 Test B-1.

(a) This test is applicable for structures in which the peak stress is negligible.

(b) This test can only be applied when σ_c is less than the yield stress of S_{yH} .

(c) The wall membrane forces from overall bending of a pipe section or vessel can be conservatively included as axisymmetrical forces.

(d) The dimensionless effective creep stress parameter Z for any combination of loading is given in Figure 8. In this Figure 8, the effective creep stress parameter Z is given by the following:

(1) Regime E

$$Z = X \quad (23)$$

(2) Regime S_1

$$Z = Y + 1 - 2\sqrt{(1-X)Y} \quad (24)$$

(3) Regimes S_2 and P

$$Z = XY \quad (25)$$

6.3.3.2 Test B-2.

(a) This test is more conservative than Test B-1 and is applicable to any structure and loading.

(b) This test can only be applied when σ_c is less than the yield stress of S_{yH} .

(c) The dimensionless effective creep stress parameter Z for any combination of loading is given in Figure 9.

6.4 STRAIN LIMITS — INELASTIC ANALYSIS

In regions expecting elevated temperatures, the maximum accumulated positive principal inelastic strain shall meet the following requirements:

- (a) strains averaged through the thickness $\leq 1\%$
- (b) strains at the surface due to an equivalent linear distribution of strain through the thickness $\leq 2\%$
- (c) local strains at any point $\leq 5\%$

7 CREEP FATIGUE EVALUATION

7.1 GENERAL REQUIREMENTS

The rules for creep fatigue evaluation discussed in this section are applicable as follows:

(a) The rules in 6.2 for Tests A-2 and A-3 are met and/or the rules for 6.3 for Tests B-1 and B-2 with $Z < 1.0$ are met. However, the contribution of stress due to radial thermal gradients to the secondary stress range may be excluded of the applicability of elastic creep fatigue rules in Tests A-2 and A-3.

(b) The rule for $(P_L + P_b + Q) \leq 3S$ is met using for $3S$ the lesser of $3S_m$ and $3\bar{S}_m$ as defined in Test A-1.

(c) Pressure induced membrane and bending stresses and thermal induced membrane stresses are classified as primary (load controlled) stresses.

7.2 CREEP FATIGUE PROCEDURE

7.2.1 Creep Procedure. The creep procedure is performed as follows:

Step 1. Determine the maximum equivalent strain range, $\Delta\varepsilon_{\max}$, from the equation

$$\Delta\varepsilon_{\max} = \frac{2S_{alt}}{E} \quad (26)$$

The value of E is determined from Section II, Part D at the same temperature as the applicable isochronous stress-strain curve.

Step 2. Determine the maximum strain, $\Delta\varepsilon_{\text{mod}}$, including the effect of stress concentration factors. The concentration factors take into account plasticity and creep effects. The modified maximum equivalent strain range, $\Delta\varepsilon_{\text{mod}}$, is calculated using the procedure specified in any one of (a), (b), or (c).

(a) The modified maximum equivalent strain range, $\Delta\varepsilon_{\text{mod}}$, may be calculated from a composite stress-strain diagram as shown in Figure 10. Figure 10 is constructed by adding the elastic stress-strain curve for the stress range S_{rH} , to the appropriate time-independent isochronous stress-strain curve from Section II, Part D, Nonmandatory Appendix E, Figures E-100.18-1 through E-100.18-15, Figures E-100.19-1 through E-100.19-15, Figures E-100.20-1 through E-100.20-12, Figures E-100.21-1 through E-100.21-11, and Figures E-100.22-1 through E-100.22-11. A conservative determination of the modi-

fied maximum equivalent strain range, $\Delta\varepsilon_{\text{mod}}$, relative to the maximum equivalent strain range, $\Delta\varepsilon_{\max}$, is given by

$$\Delta\varepsilon_{\text{mod}} = \frac{S^*}{\bar{S}} \times K_S^2 \times \Delta\varepsilon_{\max} \quad (27)$$

(b) The modified maximum equivalent strain range, $\Delta\varepsilon_{\text{mod}}$, may be calculated more accurately and less conservatively than eq. (27) by the following equation:

$$\Delta\varepsilon_{\text{mod}} = K_S^2 \times S^* \times \frac{\Delta\varepsilon_{\max}}{\Delta\sigma_{\text{mod}}} \quad (28)$$

The unknowns $\Delta\varepsilon_{\text{mod}}$ and $\Delta\sigma_{\text{mod}}$ in eq. (28) must be solved graphically or analytically by curve fitting the appropriate composite stress-strain curve.

(c) The most conservative estimate of the modified maximum equivalent strain range, $\Delta\varepsilon_{\text{mod}}$, may be obtained as

$$\Delta\varepsilon_{\text{mod}} = K_e \times K_S \times \Delta\varepsilon_{\max} \quad (29)$$

where

$$K_e = \begin{cases} 1.0 & \text{if } K_S \times \Delta\varepsilon_{\max} \leq \frac{3\bar{S}}{E} \\ K_S \times \Delta\varepsilon_{\max} \times \frac{E}{3\bar{S}} & \text{if } K_S \times \Delta\varepsilon_{\max} > \frac{3\bar{S}}{E} \end{cases}$$

Step 3. Determine the creep strain increment, $\Delta\varepsilon_c$, for the stress cycle due to load controlled stresses by using a stress intensity equal to 1.25 times the effective creep stress $\sigma_c = Z S_y$. The value of Z is obtained from 6.3.2 with the following exception: The stress cycle time including hold time between transients shall be used instead of the entire service life.

Enter the appropriate isochronous stress-strain curve for the maximum metal temperature during the stress cycle time-temperature block with the $1.25\sigma_c$ stress held constant throughout each temperature-time block of the stress cycle. The value of $\Delta\varepsilon_c$ is equal to

(a) The sum of the creep strain increment accumulated in one stress cycle time, or alternatively,

(b) The creep strain accumulated during the entire service life divided by the number of stress cycles during the entire service life.

(c) The $\Delta\varepsilon_c$ value used need not exceed 1% divided by the total number of stress cycles.

Step 4. Determine the multiaxial plasticity and Poisson's ratio adjustment factor, K_v , defined as

$$K_v = 1.0 + f(K'_v - 1.0) \quad (30)$$

where

- f = the triaxiality factor
- K'_v = the plastic Poisson ratio adjustment factor

Step 5. Determine the total strain value, ε_t , that includes elastic, plastic, and creep considerations. The total strain is given by

$$\varepsilon_t = K_v \Delta \varepsilon_{\text{mod}} + K_s \Delta \varepsilon_c \quad (31)$$

Step 6. Select the time-independent isochronous stress-strain curve from Section II, Part D, Figures E-100.18-1 through E-100.18-15, Figures E-100.19-1 through E-100.19-15, Figures E-100.20-1 through E-100.20-12, Figures E-100.21-1 through E-100.21-11, and Figures E-100.22-1 through E-100.22-11 that corresponds to the hold-time temperature, T_{HT} . Enter that stress-strain curve at strain level ε_t and establish the corresponding initial stress level, S_j .

Step 7. Account for stress relaxation, \bar{S}_r , during the average cycle time \bar{t}_j . This stress relaxation evaluation is to be performed at a constant temperature equal to T_{HT} and initial stress S_j for cycle type j . The stress relaxation history may be determined by entering the appropriate isochronous stress-strain curves of Section II, Part D, Figures E-100.18-1 through E-100.18-15, Figures E-100.19-1 through E-100.19-15, Figures E-100.20-1 through E-100.20-12, Figures E-100.21-1 through E-100.21-11, and Figures E-100.22-1 through E-100.22-11 at a strain level equal to ε_t and determining corresponding stress levels at varying times as illustrated in Figure 13. This stress relaxation process shall not be permitted to proceed to a stress level less than 1.25 times the core stress σ_c . The stress relaxation procedure results in a stress-time history similar to that illustrated in Figure 14.

Step 8. Figure 14, which is a composite stress/temperature time history envelope, is divided into q time intervals to facilitate the evaluation of creep damage. These q time intervals are selected to conveniently represent the composite stress/temperature history as a step-wise function of time. During each of these time intervals, $(\Delta t)_k$, the stress $(S)_k$, and temperature, $(T)_k$, are assumed to be constant and are selected to represent the most damaging stress/temperature combination that could exist during that time interval.

Step 9. Divide the stress $(S)_k$ for each time interval, $(\Delta t)_k$ obtained from Step 8 by the quantity K' obtained from Table 9. The K' is an approximate adjustment factor correlating results obtained from this simplified approach to results obtained from more sophisticated analyses. The quantity $(S)_k / K'$ for each time interval $(\Delta t)_k$ is then used in Table 4 to obtain time-to-rupture value, (T_d) . This process is repeated for each time increment $(\Delta t)_k$ and the following equation is solved.

$$\sum \left(\frac{\Delta t}{T_d} \right)_k \quad (32)$$

7.2.2 Fatigue Procedure. The fatigue procedure is performed as follows:

Step 1. Determine the number of applied repetitions, $(nc)_j$, of cycle type, j .

Step 2. Determine the number of design allowable cycles, $(N_d)_j$, for cycle type, j , obtained from a design fatigue data in Section II, Part D, Figures E-100.16-1 through E-100.16-5 using the maximum strain value during the cycle obtained from eq. (31).

Step 3. Calculate the ratio of n_c/N_d for all cycle types. This ratio must be equal to or less than 1.0.

$$\sum \left(\frac{n_c}{N_d} \right)_j \leq 1.0 \quad (33)$$

7.2.3 Creep-Fatigue Interaction. Section VII, Division 2, eq. (5-G.39) for creep rupture and eq. (5-G.33) for fatigue are combined as follows:

$$\sum \left(\frac{\Delta t}{T_d} \right)_k + \sum \left(\frac{n_c}{N_d} \right)_j \leq D \quad (34)$$

Compliance with eq. (34) is obtained from Figure 15.

8 NOMENCLATURE

D = value in Figure 15 encompassed by the horizontal axis, vertical axis, and the curve associated with a given material

$\Delta \varepsilon_{\text{max}}$ = the maximum equivalent strain range as obtained from eq. (31)

$\Delta \varepsilon_{\text{mod}}$ = the modified maximum equivalent strain range that account for the effects of local plasticity and creep

ε_i = the creep strain that would be expected from a stress level of $1.25S_j$ at the operating temperature applied for the total duration of time during the service lifetime that the metal is at operating temperature

E = elastic modulus of elasticity

f = triaxiality factor obtained from Figure 11

K = shape factor based in plastic analysis, for rectangular sections, $K = 1.5$

K_s = either the equivalent stress concentration factor, as determined by test or analysis, or the maximum value of the theoretical elastic stress concentration factor in any direction for the local area under consideration. The equivalent stress concentration factor is defined as the effective (von Mises) primary plus secondary plus peak stress divided by the effective primary plus secondary stress. Note that fatigue strength reduction factors developed from low temperature continuous cycling fatigue tests may not be acceptable

- for defining K_t when creep effects are not negligible.
- K_t = shape factor based on creep analysis. For rectangular sections, $K_t = (3n)/(1 + 2n)$ where n is the exponent in Norton's creep equation. K_t is equal to 1.25 in this Code Case
- K_v = multiaxial plasticity and Poisson ratio adjustment factor
- K'_v = plastic Poisson ratio adjustment factor determined from Figure 12
- O = origin of the composite isochronous stress-strain curve, Figure 10, used in the analysis
- O' = origin of the time-independent isochronous stress-strain curve of Section II, Part D, Figures E-100.18-1 through E-100.18-15, Figures E-100.19-1 through E-100.19-15, Figures E-100.20-1 through E-100.20-12, Figures E-100.21-1 through E-100.21-11, and Figures E-100.22-1 through E-100.22-11
- P_{1L} = pressure induced and thermally induced local membrane stress
- P_{1b} = pressure induced primary plus secondary bending stress
- Q_1 = thermally induced secondary stress
- R = the appropriate ratio of the weld metal creep rupture strength to the base metal creep rupture strength. Values are shown in Section II, Part D, Figures E-100.5-1 through E-100.5-5. The lowest S_t value of the adjacent base metal shall be utilized for the weldment.
- r = defined in t_{id}
- S = the maximum allowable value of general primary membrane equivalent stress. Values are shown in Section II, Part D, Table 5A and 5B
- S^* = the stress indicator determined by entering the stress-strain curve of Section II, Part D, Figures E-100.18-1 through E-100.18-15, Figures E-100.19-1 through E-100.19-15, Figures E-100.20-1 through E-100.20-12, Figures E-100.21-1 through E-100.21-11, and Figures E-100.22-1 through E-100.22-11 at strain range of $\Delta\epsilon_{max}$
- \bar{S} = the stress indicator determined by entering the stress-strain curve of Section II, Part D, Figures E-100.18-1 through E-100.18-15, Figures E-100.19-1 through E-100.19-15, Figures E-100.20-1 through E-100.20-12, Figures E-100.21-1 through E-100.21-11, and Figures E-100.22-1 through E-100.22-11 at a strain range of $K\Delta\epsilon_{max}$
- $2S_{alt} = (P_L + P_b + Q)$ at a given point
- S_m = the lowest stress value at a given temperature among the time independent strength quantities in Section II, Part D and extended to elevated temperature. Stress values are listed in Section II, Part D, Figures E-100.4-1 through E-100.4-5.
- S_{mt} = for base material, the allowable limit of general primary membrane equivalent stress. Values are shown in Section II, Part D, Figures E-100.4-1 through E-100.4-5. The S_{mt} values are the lower of two equivalent stress values, S_m (time-independent) and S_t (time-dependent).
- = for weldments, it shall be taken as the lower of the S_{mt} values in Section II, Part D, Figures E-100.4-1 through E-100.4-5 or $0.8S_r \times R$.
- S_r = the expected minimum stress-to-rupture strength. Values for base materials are shown in Section II, Part D, Figures E-100.7-1 through E-100.7-6. Weld materials strength reduction values are shown in Section II, Part D, Tables E-100.8-1 through E-100.8-3, Tables E-100.9-1 through E-100.9-3, and Tables E-100.10-1, E-100.10-2, E-100.11-1 and E-100.12-1.
- S_{rH} = relaxation stress at the hot end of a cycle
- S_{rL} = relaxation stress at the cold end of a cycle
- S_t = for base material, a temperature and time-dependent equivalent stress limit. Values are shown in Section II, Part D, Figures E-100.5-1 through E-100.5-5. The data considered in establishing these values are obtained from long-term constant-load uniaxial tests. For each specific time, t , the S_t values shall be the least of:
- 100% of the average stress required to obtain a total (elastic, plastic, primary, and secondary creep) strain of 1%
 - 80% of the minimum stress to cause initiation of tertiary creep
 - 67% of the minimum stress to cause rupture
- = for weldments, it shall be taken as the lower of the S_t values in Section II, Part D, Figures E-100.5-1 through E-100.5-5 or $0.8 S_t \times R$.
- S_u = tensile strength of the material. Values are shown in Section II, Part D, Table E-100.1-1
- S_y = yield stress. Values are shown in Section II, Part D, Table E-100.6-1
- S_{ya} = the average of the S_y values at the maximum and minimum wall averaged temperatures during the cycle being considered
- S_{yH} = yield stress of the wall averaged temperature at the hot end of the cycle
- S_{yL} = yield stress of the wall averaged temperature at the low end of the cycle
- s = defined in t_{id}
- t_i = the total duration of a specific loading P_{mi} at elevated temperature, T , during the entire service life of the component

t_{ib} = the time value determine by entering Section II, Part D, Figures E-100.7-1 through E-100.7-6 at a value of stress equal to $(P_L + P_b/K_t)$

t_{id} = the time value determined by entering Section II, Part D, Figures E-100.7-1 through E-100.7-6 (stress to rupture) at a value of stress equal to a factor, s , times the yield stress, S_y , associated with T_i . The s factor is based on the combined effects of cyclic strain hardening, a factor of 1.2, (or softening, a factor of 0.8) and a factor of 1.25 to convert from minimum to average yield strength. The time to rupture factor, r , accounts for the effect of cyclic softening on minimum creep rupture strength. The values of r and s are shown in Table 6. If S_y is above the stress values in Figures E-100.7-1 through

E-100.7-6, this test cannot be satisfied. When S_y is below the lowest stress value provided in Figures E-100.7-1 through E-100.7-6, the constant temperature line may be extrapolated to larger t_{id} values using the steepest slope on Figure 3 for the material.

t_{im} = maximum allowed time under the load, S_b , as determined from Section II, Part D, Figures E-100.5-1 through E-100.5-5

$$X = P_m/S_y$$

P_m = general membrane stress

$$Y = \Delta Q/ S_y$$

ΔQ = range of thermal stress calculated elastically

Table 1
Permissible Base Materials for Structures Other Than Bolting

Base Material	Spec. No.	Product Form	Types, Grades, or Classes	
Types 304 SS and 316 SS [Note (1)], [Note (2)], [Note (3)]	SA-182	Fittings & Forgings	F 304, F 304H, F 316, F 316H	
	SA-213	Smls. Tube	TP 304, TP 304H, TP 316, TP 316H	
	SA-240	Plate	304, 316, 304H, 316H	
	SA-249	Welded Tube	TP 304, TP 304H, TP 316, TP 316H	
	SA-312	Welded & Smls. Pipe	TP 304, TP 304H, TP 316, TP 316H	
	SA-358	Welded Pipe	304, 316, 304H, 316H	
	SA-376	Smls. Pipe	TP 304, TP 304H, TP 316, TP 316H	
	SA-403	Fittings	WP 304, WP 304H, WP 316, WP 316H, WP 304W, WP 304HW, WP 316W, WP 316HW	
	SA-479	Bar	304, 304H, 316, 316H	
	SA-965	Forgings	F 304, F 304H, F 316, F 316H	
	SA-430	Forged & Bored Pipe	FP 304, FP 304H, FP 316, FP 316H	
	Ni-Fe-Cr (Alloy 800H) [Note (4)]	SB-163	Smls. Tubes	UNS N08810
		SB-407	Smls. Pipe & Tube	UNS N08810
SB-408		Rod & Bar	UNS N08810	
SB-409		Plate, Sheet, & Strip	UNS N08810	
SB-564		Forgings	UNS N08810	
2 ¹ / ₄ Cr-1Mo [Note (5)]	SA-182	Forgings	F 22, Class 1	
	SA-213	Smls. Tube	T 22	
	SA-234	Piping Fittings	WP 22, WP 22W [Note (6)]	
	SA-335	Forg. Pipe	P 22	
	SA-336	Fittings, Forgings	F 22a	
	SA-369	Forg. Pipe	FP 22	
	SA-387	Plate	Gr 22, Class 1	
	SA-691	Welded Pipe	Pipe 2 ¹ / ₄ Cr-1Mo (SA-387, Gr. 22, Cl. 1)	
9Cr-1Mo-V	SA-182	Forgings	F91	
	SA-213	Smls. Tube	T91	
	SA-335	Smls. Pipe	P91	
	SA-387	Plate	91	

NOTES:

- (1) These materials shall have a minimum specified room temperature yield strength of 30,000 psi (207 MPa) and a minimum specified carbon content of 0.04%.
- (2) For use at temperatures above 1,000 °F (540°C), these materials may be used only if the material is heat treated by heating to a minimum temperature of 1,900 °F (1 040°C) and quenching in water or rapidly cooling by other means.
- (3) Section II, Part D, Table E-100.23-1 provides nonmandatory guidelines on additional specification restrictions to improve performance in certain service applications.
- (4) These materials shall have a total aluminum-plus-titanium content of at least 0.50% and shall have been heat treated at a temperature of 2,050°F (1 120°C) or higher.
- (5) This material shall have a minimum specified room temperature yield strength of 30,000 psi (207 MPa), a minimum specified room temperature ultimate strength of 60,000 psi (414 MPa), a maximum specified room temperature ultimate strength of 85,000 psi (586 MPa), and a minimum specified carbon content of 0.07%.
- (6) The material allowed under SA-234 shall correspond to one of:
 - (a) SA-335, Grade P 22
 - (b) SA-387, Grade 22, Class 1
 - (c) SA-182, Grade F 22, Class 1 in compliance with [Note (4)].

Table 2
Temperature and Service Life Limitations

Material	Low Temperature, °F	High Temperature, °F	Life, hr
Type 304SS	800	1,500	300,000
Type 316SS	800	1,500	300,000
Ni-Fe-Cr (Alloy 800H)	800	1,400	300,000
2.25Cr-1Mo	700	1,100	300,000
9Cr-1Mo-V	700	1,200	300,000

Table 3
Permissible Weld Materials

Base Material	Spec. No.	Class
Types 304 SS and 316 SS	SFA-5.4	E 308, E 308L, E 316, E 316L, E 16-8-2
	SFA-5.9	ER 308, ER 308L, ER 316, ER 316L, ER 16-8-2
	SFA-5.22	E 308, E 308T, E 308LT, E 316T, E316LT-1 EXXXT-G (16-8-2 chemistry)
Ni-Fe-Cr (Alloy 800H)	SFA-5.11	ENiCrFe-2
	SFA-5.14	ERNiCr-3
2 ¹ / ₄ Cr-1Mo	SFA-5.5	E 90XX-B3 (>0.05% Carbon)
	SFA-5.23	EB 3, ECB 3
	SFA-5.28	E 90C-B3 (>0.05% Carbon), ER 90S-B3
	SFA-5.29	E 90T-B3 (>0.05% Carbon)
9Cr-1Mo-V	SFA-5.5	E90XX-B9
	SFA-5.23	EB9
	SFA-5.28	ER90S-B9

Table 4
Stress Values

Stress	Table/Figure in Section II, Part D, Nonmandatory Appendix E
Allowable stress, S_{mt}	Figures E-100.4-1 through E-100.4-5
Allowable stress, S_t	Figures E-100.5-1 through E-100.5-5
Yield stress, S_y	Table E-100.6-1
Stress-to-rupture, S_r	Figures E-100.7-1 through E-100.7-4 and E-100.7-6
Stress-to-rupture for welds, S_r	Tables E-100.8-1 through E-100.8-3, Tables E-100.9-1 through E-100.9-3, and Tables E-100.10-1, E-100.10-2, E-100.11-1, and E-100.12-1
Isochronous curves	Figures E-100.18-1 through E-100.18-15, Figures E-100.19-1 through E-100.19-15, Figures E-100.20-1 through E-100.20-12, Figures E-100.21-1 through E-100.21-11, and Figures E-100.22-1 through E-100.22-11

Table 5
Short-Term Reduction Factor C_1

Material	Operating Temperature, °F	Reduction Factor, S_y	Reduction Factor, S_u
Type 304SS	≥900	1.0	0.8
Type 316SS	≥900	1.0	0.8
Ni-Fe-Cr (Alloy 800H)	≥1,350	0.9	0.9
2.25Cr-1Mo	800	1.0	0.94
	850	0.92	0.88
	900	0.86	0.82
	950	0.80	0.77
	1,000	0.74	0.72
	1,050	0.67	0.67
	1,100	0.63	0.62
9Cr-1Mo-V	900	1.0	0.97
	950	1.0	0.93
	1,000	1.0	0.90
	1,050	1.0	0.84
	1,100	1.0	0.84
	1,150	1.0	0.81
	1,200	1.0	0.78

Table 6
Values of Parameters r and s

Material	Parameter r	Parameter s
Type 304SS	1.0	1.5
Type 316SS	1.0	1.5
Ni-Fe-Cr (Alloy 800H)	1.0	1.5
2.25Cr-1Mo	1.0	1.5
9Cr-1Mo-V	0.1	1.0

Table 7
Minimum Temperature for Test A-1

Material	Temperature, °F (°C)
Type 304SS	800 (427)
Type 316SS	800 (427)
Ni-Fe-Cr (Alloy 800H)	800 (427)
2.25Cr-1Mo	700 (371)
9Cr-1Mo-V	700 (371)

Table 8
Temperatures at Which $S = S_y$ at 10^5 hr for Tests A-3, B-1, and B-2

Material	Temperature, °F (°C)
Type 304SS	948 (509)
Type 316SS	1,011 (544)
Ni-Fe-Cr (Alloy 800H)	1,064 (573)
2.25Cr-1Mo	801 (427)
9Cr-1Mo-V	940 (504)

Table 9
 K' Values

Material	K' Elastic Analysis	K' Inelastic Analysis
2.25Cr-1Mo	0.9	0.67
9Cr-1Mo-V	1.0	0.87
Ni-Fe-Cr (Alloy 800H)	0.9	0.67
Types 304SS and 316SS	0.9	0.67

Figure 1
General Outline of Strain Deformation Procedure for Creep Fatigue Analysis

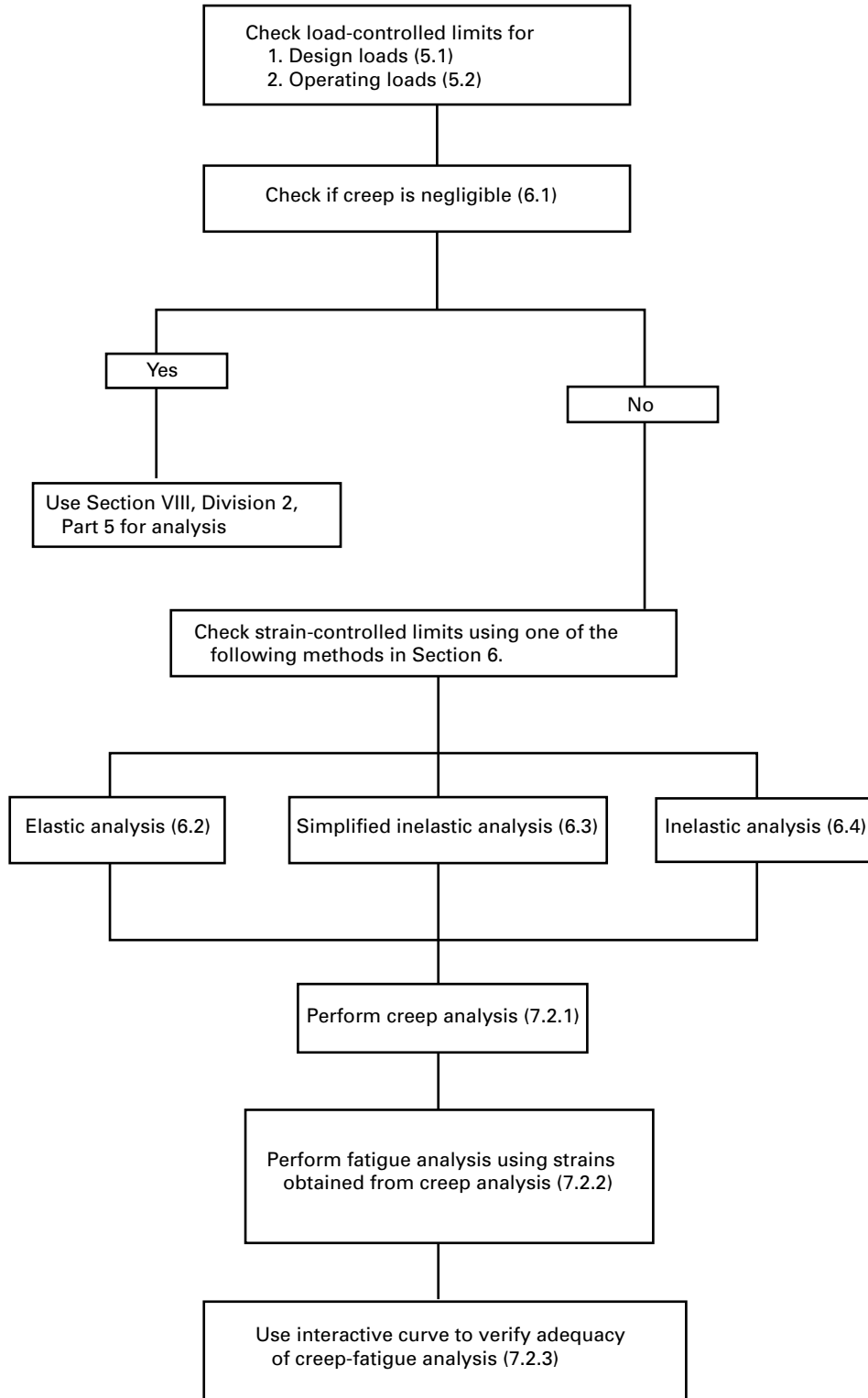


Figure 2
Flow Diagram for Load-Controlled Stress Limits

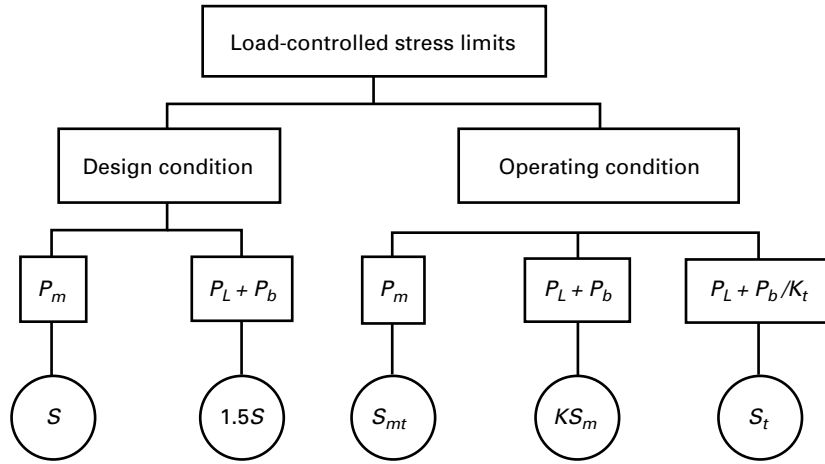


Figure 3
Use-Fractions for Membrane Stress

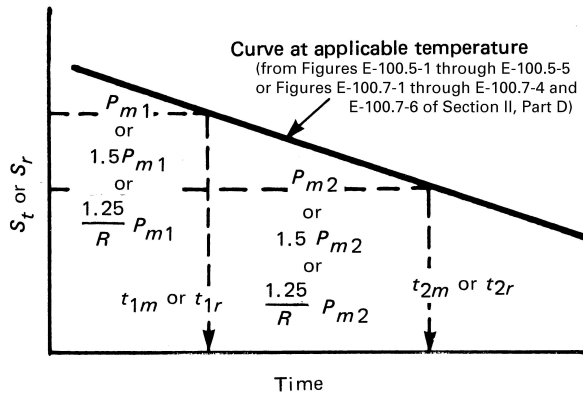


Figure 4
Use-Fractions for Membrane Plus Bending Stress

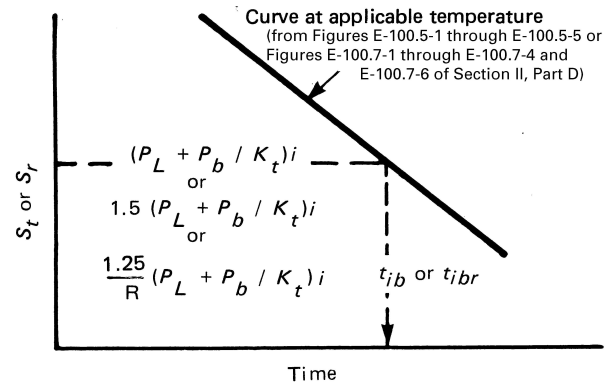
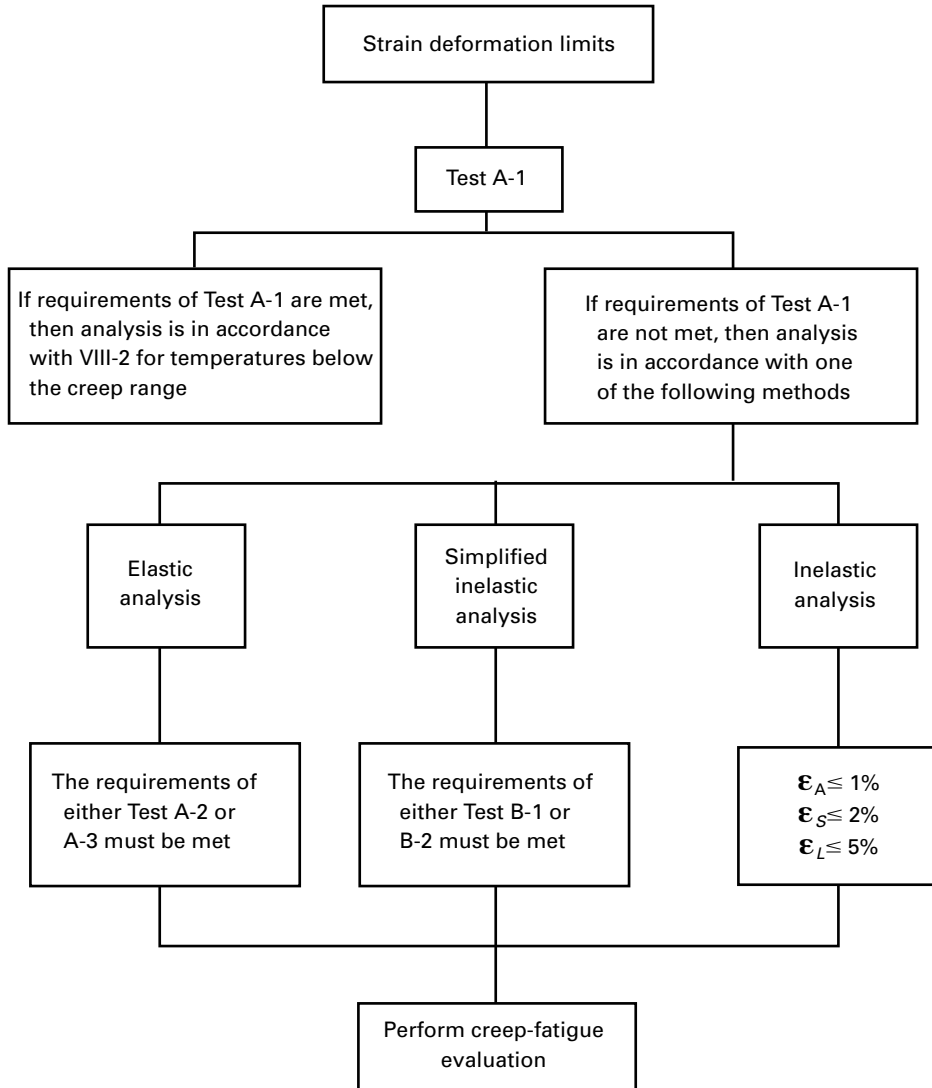


Figure 5
Requirements for Strain Limits



Legend:

ϵ_A = strain averaged through thickness

ϵ_L = local strain

ϵ_S = strain at surface

Figure 6
Stress Criteria for Test A-1

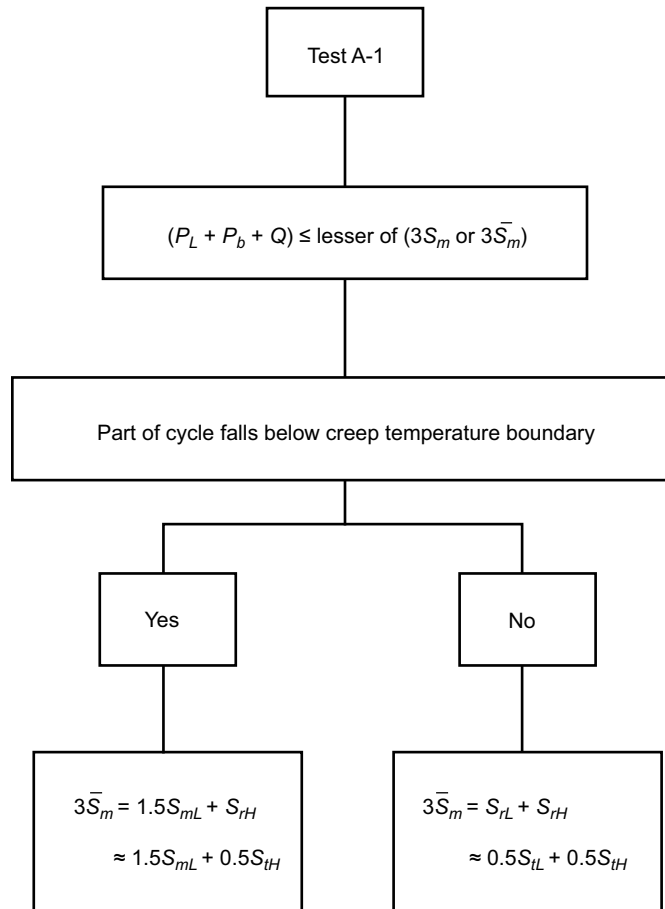


Figure 7
General Requirements for Tests A-2 and A-3

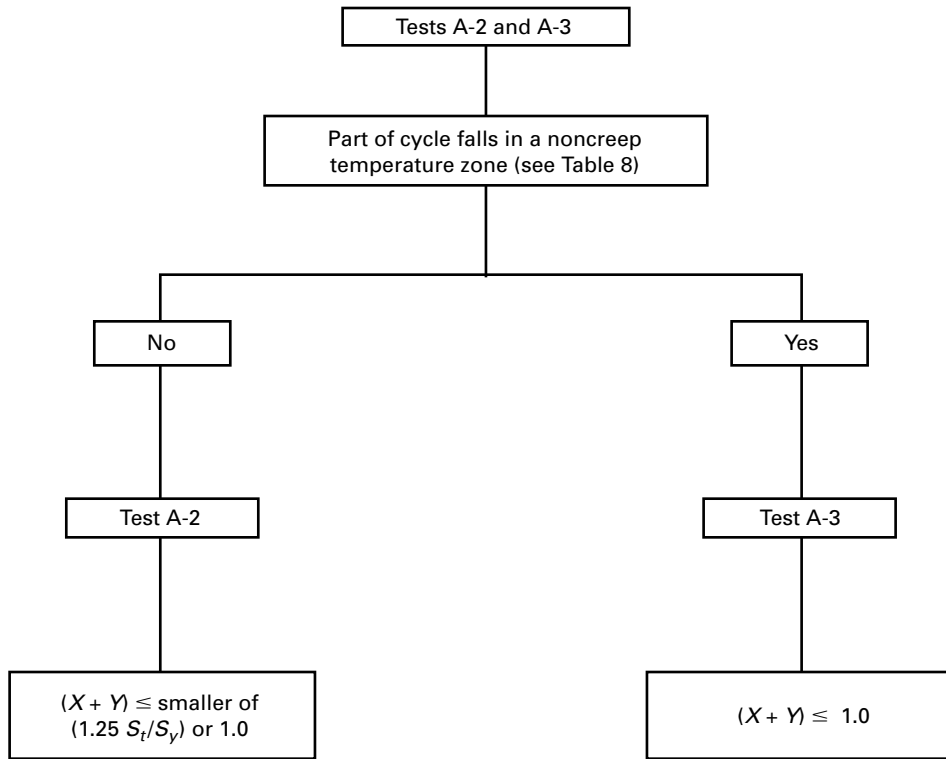
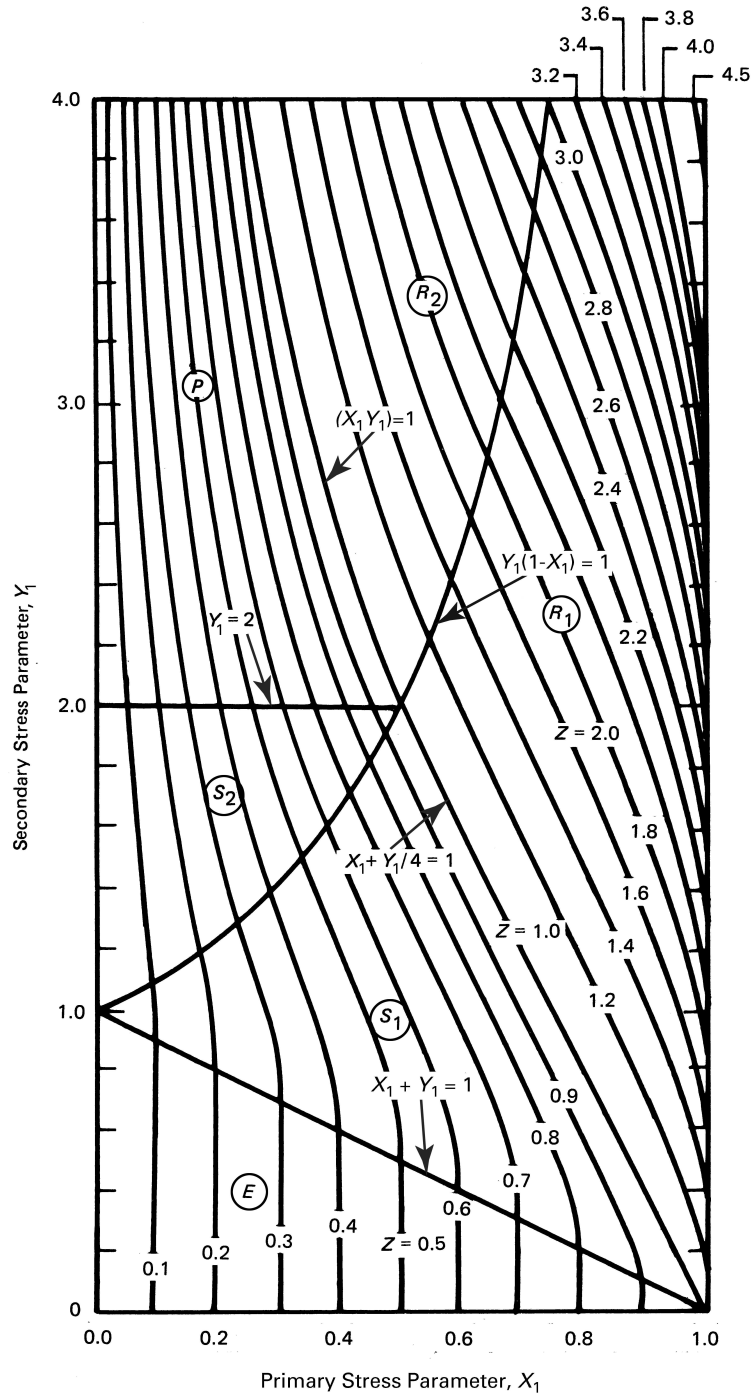


Figure 8
Effective Creep-Stress Parameter, Z, for Simplified Elastic Analysis Using Test B-1



GENERAL NOTE: This figure is divided into the following six regimes: *E*, *S*₁, *S*₂, *P*, *R*₁, and *R*₂. The characteristics of these regimes are as follows:

- (1) Regime *E*
 - (a) Stress is elastic below the creep range.
 - (b) Ratcheting does not occur below the creep range.
 - (c) Stress redistributes to elastic value above the creep range.
- (2) Regime *P*
 - (a) Shakedown is not possible below as well as in the creep range.
 - (b) Failure occurs due to low cycle fatigue below the creep range.

Figure 8
Effective Creep-Stress Parameter, Z, for Simplified Elastic Analysis Using Test B-1 (Cont'd)

GENERAL NOTE (Cont'd)

- (3) Regime S_1
 - (a) Ratcheting does not occur below the creep range.
 - (b) Ratcheting occurs in the creep range.
 - (c) Shakedown is not possible in the creep range.
- (4) Regime S_2
 - (a) Ratcheting does not occur below the creep range
 - (b) Ratcheting occurs in the creep range.
 - (c) Shakedown is not possible in the creep range.
- (5) Regime R_1
 - (a) Ratcheting occurs below as well as in the creep range.
 - (b) Shakedown is not possible below as well as in the creep range.
- (6) Regime R_2
 - (a) Ratcheting occurs below as well as in the creep range.
 - (b) Shakedown is not possible below as well as in the creep range.

Figure 9
Effective Creep-Stress Parameter, Z, for Simplified Inelastic Analysis Using Test B-2

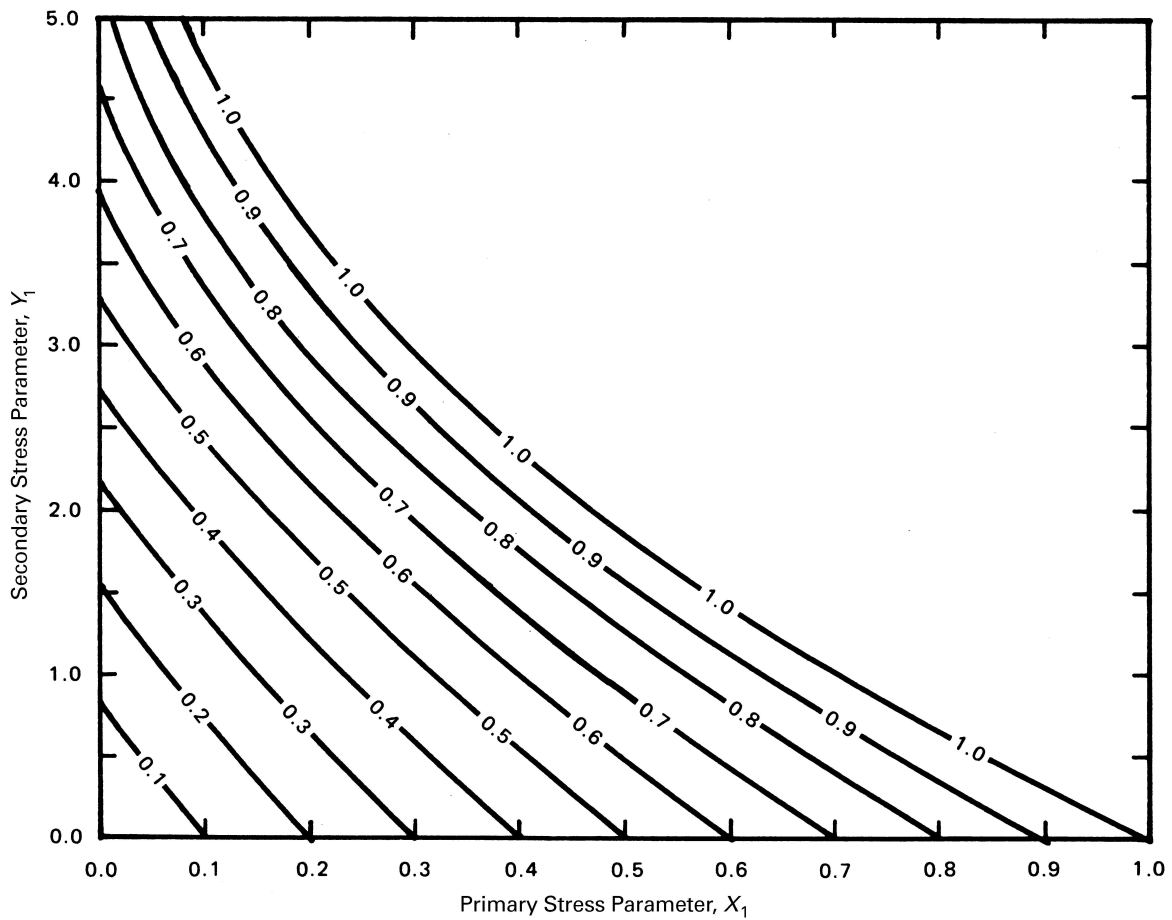
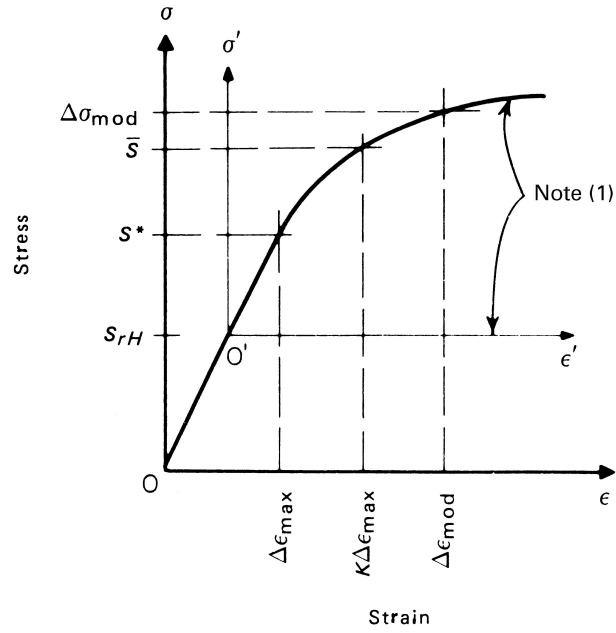
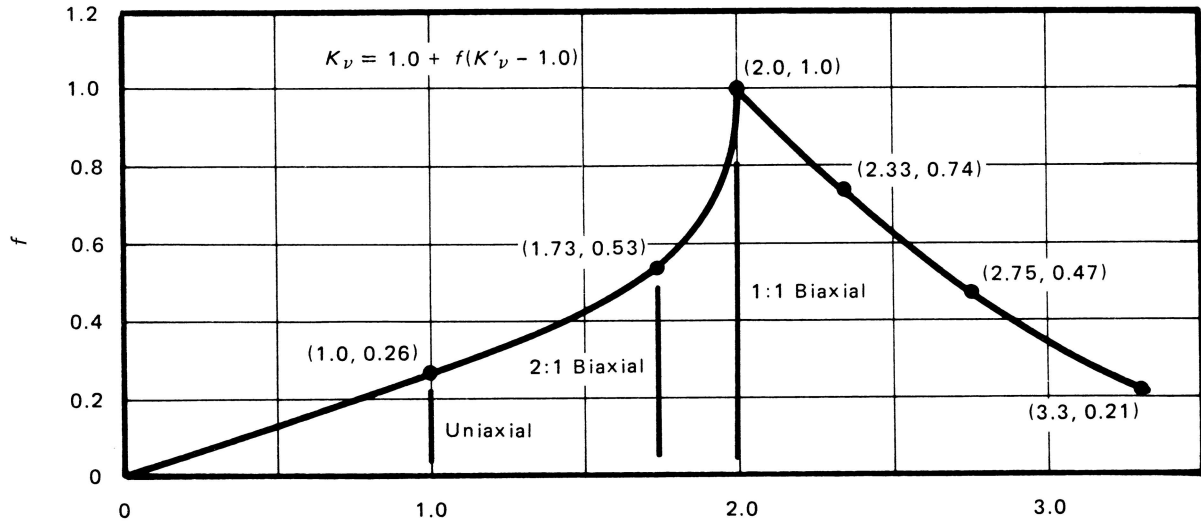


Figure 10
Stress-Strain Relationship



NOTE: (1) Zero time σ' - ϵ' curve with σ' , ϵ' coordinates same as Figures E-100.18-1 through E-100.18-15, Figures E-100.19-1 through E-100.19-15, Figures E-100.20-1 through E-100.20-12, Figures E-100.21-1 through E-100.21-11, and Figures E-100.22-1 through E-100.22-11 isochronous curves.

Figure 11
Inelastic Multiaxial Adjustments



$$T.F. = \frac{|\sigma_1 + \sigma_2 + \sigma_3|}{\frac{1}{\sqrt{2}} \left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \right]^{1/2}}$$

σ 's are principal stresses at extreme of stress cycle.

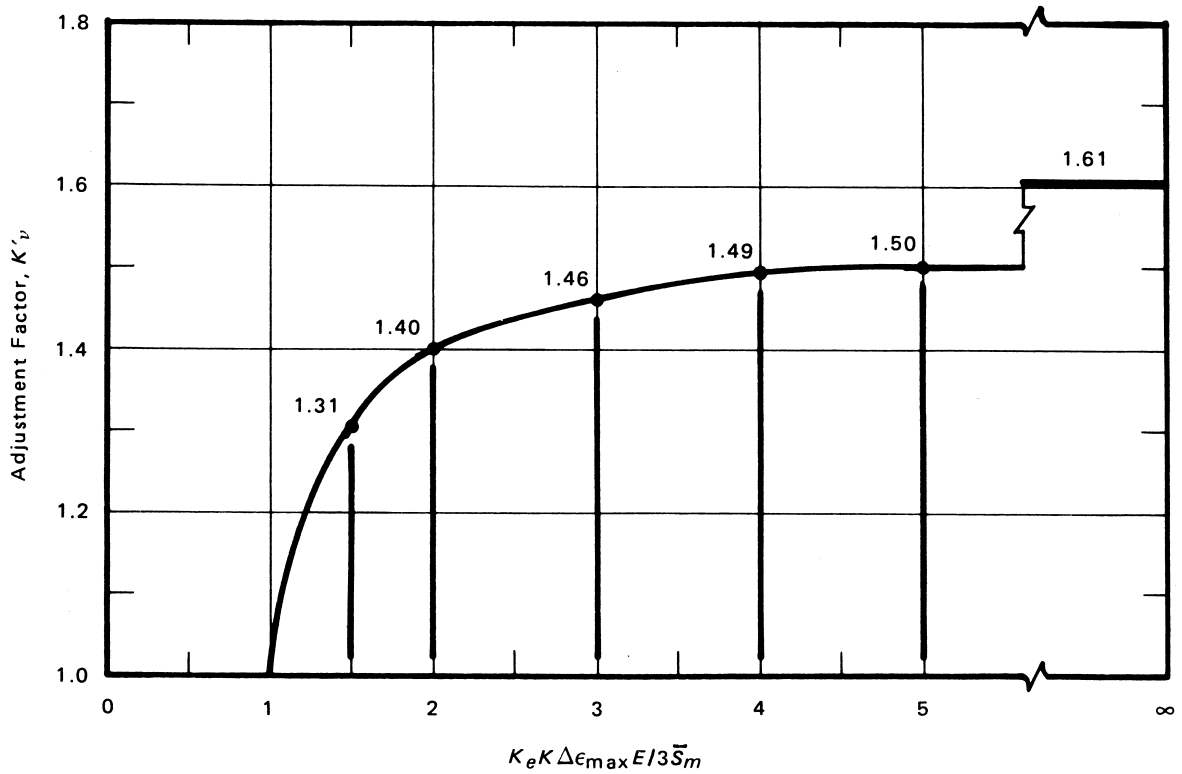
GENERAL NOTE: See equation below.

$$f = \frac{C_1 + C_2(T.F.) + C_3(T.F.)^2 + C_4(T.F.)^3}{1 + C_5(T.F.) + C_6(T.F.)^2 + C_7(T.F.)^3}$$

where

C Constants	0 < T.F. ≤ 1.73	1.73 < T.F. ≤ 2.0	2.0 < T.F. ≤ 3.3
C_1	0	0.367366	8.95
C_2	0.293	-0.53533476	-2.2882395
C_3	0	0.26042254	0
C_4	0	-0.042291728	0
C_5	0.283322	-1.4919987	1.6812905
C_6	-0.177575	0.74301006	0
C_7	0	-0.1234988	0

Figure 12
Adjustment for Inelastic Biaxial Poisson's Ratio



GENERAL NOTE: The curve for K'_v can be expressed as follows:

(1) For $\gamma \leq 1.0$

$$K'_v = 1.0$$

(2) For $1.0 < \gamma \leq 50$

$$K'_v = \frac{C_1 + C_2 \gamma}{1 + C_3 \gamma + C_4 \gamma^2}$$

(3) For $\gamma > 50$

$$K'_v = 1.61$$

where

$$C_1 = 1.88$$

$$C_2 = -2.5037475$$

$$C_3 = -1.6255583$$

$$C_4 = 0.0014771927$$

$$\gamma = K_e K \Delta \epsilon_{max} E / 3 \bar{S}_m$$

Figure 13
Method for Determining Stress Relaxation From Isochronous Curves

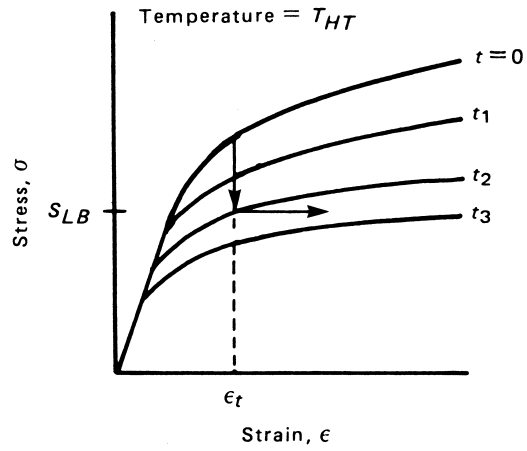


Figure 14
Stress-Relaxation Limits for Creep Damage

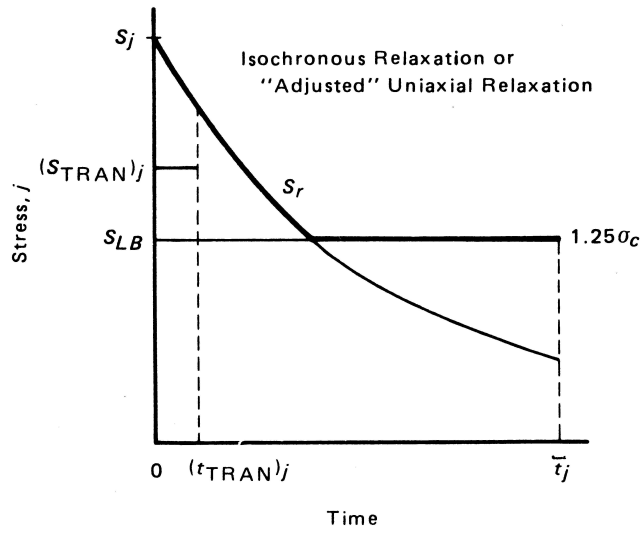
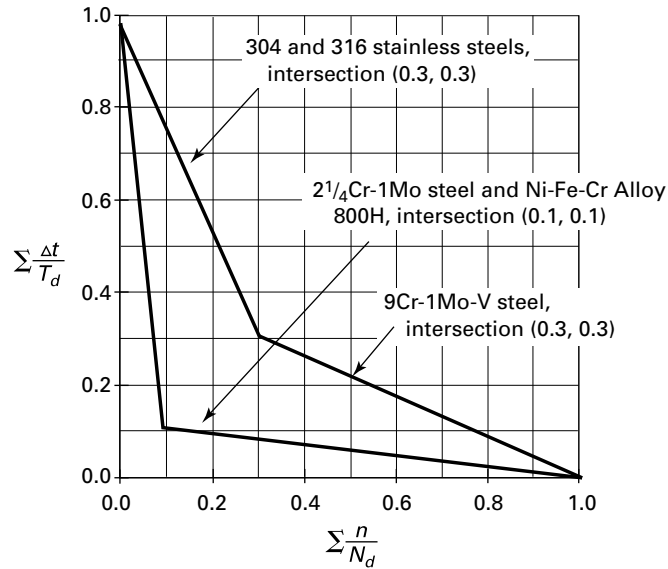


Figure 15
Creep-Fatigue Damage Envelope



GENERAL NOTE: The following equations apply to this figure.

(1) For 304 stainless steel, 316 stainless steel, and 9Cr-1Mo-V steel

(a) For $0 < \Sigma \left(\frac{n}{N_d} \right) \leq 0.3$

$$\Sigma \frac{\Delta t}{T_d} = -2.333 \Sigma \frac{n}{N_d} + 1$$

(b) For $0.3 < \Sigma \left(\frac{n}{N_d} \right) \leq 1.0$

$$\Sigma \frac{\Delta t}{T_d} = -0.429 \Sigma \frac{n}{N_d} + 0.429$$

(2) For nickel alloy 800H and 2.25Cr-1Mo steel

(a) For $0 < \Sigma \left(\frac{n}{N_d} \right) \leq 0.1$

$$\Sigma \frac{\Delta t}{T_d} = -9 \Sigma \frac{n}{N_d} + 1$$

(b) For $0.1 < \Sigma \left(\frac{n}{N_d} \right) \leq 1.0$

$$\Sigma \frac{\Delta t}{T_d} = -0.111 \Sigma \frac{n}{N_d} + 0.111$$

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Case 2844

Implementation of Changes in Division 1, 31-4 (a) and (b) and Division 2, 3.4.4.1 and 3.4.4.2

Section VIII, Division 1; Section VIII, Division 2

Approval Date: December 9, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May welding procedure qualifications and welding consumables testing in Division 1, 31-4 (a) and (b), and Division 2, 3.4.4.1 and 3.4.4.2, respectively, be revised as shown in this Case?

Reply: It is the opinion of the Committee that welding procedure qualifications and welding consumables testing in Division 1, 31-4 (a) and (b), and Division 2, 3.4.4.1 and 3.4.4.2, respectively, may be revised to clarify the requirements as follows:

(a) Division 1, 31-4 (a) and Division 2, 3.4.4.1. Welding procedure qualifications using welding consumables of the same classification or trade designation as those to be used in production shall be made for material welded to itself or to other materials. The qualifications shall conform to the requirements of Section IX, and the

maximum tensile strength at room temperature shall be 760 MPa (110 ksi) (for heat treatment Conditions A and B). Welding shall be limited to submerged-arc (SAW) and shielded metal-arc (SMAW) processes for 3Cr-1Mo- $\frac{1}{4}$ V-Ti-B material only.

(b) Division 1, 31-4 (b) and Division 2, 3.4.4.2. Weld metal from each heat or lot of electrodes and filler wire-flux combination shall be tested, unless specific heat or lot traceable test reports meeting the additional requirements of Division 1, Mandatory Appendix 31 and Division 2, 3.4, respectively, related to welding consumables testing have been provided by the welding consumables manufacturer. The minimum and maximum tensile properties shall be met in postweld heat treated (PWHT) Conditions A and B. The minimum Charpy V-notch impact properties shall be met in PWHT Condition B. Testing shall be in general conformance with SFA-5.5 for covered electrodes and SFA-5.23 for filler wire-flux combinations.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2847-1

Use of Round Steel Wire

Section VIII, Division 3

Approval Date: December 12, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may round steel wire be used for the construction of wire-wound pressure vessels for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that round steel wire may be used for wire-wound pressure vessels under the rules of Section VIII, Division 3, provided the wire meets all requirements of SA-905, and the following additional requirements are met:

(a) The wire shall have a round cross section.

(b) The design temperature shall not exceed 200°F (93°C).

(c) The wire shall meet the chemical, tensile, and dimensional requirements from Tables 1, 2, and 3, respectively, for diameters greater than or equal to 0.014 in. (0.36 mm) and less than 0.020 in. (0.51 mm).

(d) The chemical, tensile, and dimensional requirements for diameters 0.020 in. (0.51 mm) and above shall meet the requirements of SA-905, Class 1 for the corresponding wire thickness. Diametric variation will be based on the corresponding thickness variation in SA-905.

(e) The yield strength values in Section II, Part D, Subpart 1, Table Y-1 for SA-905, Class 1 material with a thickness of 0.020 in. (0.51 mm) shall be used in conjunction with Tables 4 and 4M of this Case for interpolation for wire sizes greater than 0.014 in. (0.36 mm) but less than 0.020 in. (0.51 mm) for design. The yield values for thicknesses above 0.020 in. (0.51 mm) listed in Table Y-1 for SA-905, Class 1 shall be used for corresponding diameters in design.

(f) The standard 10 in. (254 mm) gage length contained in SA-370 shall be used in lieu of SA-905, para. 6.1.3 for determination of elongation.

(g) The wire for this Case shall only be used when manufacturing vessels following Case 2836.

(h) Caution is advised when using this wire material as it may be more susceptible than lower strength materials to environmental stress corrosion cracking and/or embrittlement due to hydrogen exposure. This susceptibility increases as yield strength increases. The designer shall consider these effects and their influence on the vessel. See Section II, Part D, Nonmandatory Appendix A, A-701 and A-702.

(i) This Case number shall be shown on the marking and certification of the material and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.75–0.95
Manganese	0.30–0.60
Phosphorus, max.	0.025
Sulphur, max.	0.02
Silicon	0.10–0.30

Table 2
Tensile Requirements at Room Temperature

Thickness, in. (mm)	Tensile Strength, min., ksi (MPa)	Yield Strength, min., ksi (MPa)	Elongation, min., %
0.014 (0.36)	299 (2060)	264 (1820)	2

GENERAL NOTE: Determination of tensile properties and permanent elongation shall be in accordance with SA-370.

Table 3
Permissible Variation in Dimension

Diameter, in. (mm)	Permissible Variation, ± in. (± mm)
0.014 to 0.020 (0.36 to 0.51), incl.	0.0004 (0.01)

Table 4
Design Yield Strength Values

Temperature, °F	Yield Strength, ksi
-20 to 100	264
150	256
200	247

GENERAL NOTE: For diameter of 0.014 in.

Table 4M
Design Yield Strength Values

Temperature, °C	Yield Strength, MPa
-30 to 40	1820
65	1763
100	1691

GENERAL NOTE: For diameter of 0.36 mm.

Case 2848

Resistance Welding for Fittings and Nozzles

Section IV

Approval Date: January 20, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it allowed to perform fitting and nozzles connections by resistance welding for H-stamped products?

Reply: It is the opinion of the Committee that resistance welding may be used for the attachment of fittings and nozzles under the following requirements:

(a) The welding process utilized shall be limited to projection welding.

(b) Materials used in projection welding parts shall be limited to a maximum carbon content of 0.15%.

(c) The nominal thickness of vessel material shall not exceed $\frac{5}{16}$ in. (8 mm), and the fitting shall not exceed NPS 2 (DN 50).

(d) The maximum allowable working pressure for a vessel with fittings attached by projection welding shall be established by a proof test in accordance with HG-502.3.

(e) Procedure and performance qualification shall meet the following Section IX requirements:

(1) Projection welding machine qualification shall meet the requirements of QW-284.

(2) Projection weld procedure qualification shall meet the requirements of QW-285.

(3) Projection welding operator qualification shall meet the requirements of QW-384.

(f) All other requirements of Section IV shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2849

Use of Austenitic Stainless Steel SA-312/SA-312M Type 316Ti (UNS S31635) in the Construction of Heating Boilers

Section IV

Approval Date: January 20, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may austenitic stainless steel SA-312/SA-312M Type 316Ti, UNS S31635, be used in the construction of heating boilers under Section IV?

Reply: It is the opinion of the Committee that austenitic stainless steel SA-312/SA-312M Type 316Ti, UNS S31635, may be used in Section IV heating boiler construction, provided the following requirements are met:

(a) The allowable stresses shall be as listed in [Tables 1](#) and [1M](#).

(b) The maximum design temperature shall be 400°F (225°C).

(c) For welding, P-No. 8 shall apply.

(d) External pressure per Section II, Part D, Subpart 3, Figure HA-2 applies to this material.

(e) All other applicable requirements of Section IV shall apply.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, Seamless, ksi	Maximum Allowable Stress Values, Welded, ksi
75	15.0	12.8
100	15.0	12.8
150	15.0	12.8
200	15.0	12.8
250	15.0	12.8
300	15.0	12.8
350	15.0	12.8
400	14.3	12.2

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, Seamless, MPa	Maximum Allowable Stress Values, Welded, MPa
21	103	87.6
40	103	87.9
65	103	87.9
100	103	87.9
125	103	87.9
150	103	87.9
175	103	87.9
200	99.3	84.4
225	95.3	81.0

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Case 2851

Use of ASME B31.1, 2014 Edition

Section I

Approval Date: February 9, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the 2014 Edition of ASME B31.1 be used in lieu of the 2012 Edition for the construction on boiler external piping in Section I boilers?

Reply: It is the opinion of the Committee that the 2014 Edition of ASME B31.1 may be used in lieu of the 2012 Edition for the construction of boiler external piping. Notes 1, 2, and 3 of Table A-360, Section I shall apply. This Case number shall be shown on the Manufacturer's Data Report.

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Case 2853

Class III Composite Pressure Vessels Maximum Design Temperature

Section X

Approval Date: March 30, 2015

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions and requirements may a Class III composite pressure vessel be designed and constructed to a maximum design temperature of 250°F (121°C) using the rules of Section X for Class III vessels with nonload-sharing liners?

Reply: It is the opinion of the Committee that a Class III composite pressure vessel may be designed and constructed under the rules of Section X, Mandatory Appendix 8, with a maximum design temperature of 250°F (121°C), provided the following requirements are met:

(a) All requirements of 8-400.3 shall be met at the Maximum Design Temperature, which in no case shall exceed 250°F (121°C).

(b) All requirements of 8-700.5.5 shall be met with the pressure vessel at the greater of 185°F (85°C) or the Maximum Design Temperature.

(c) For each resin and curing agent batch, the glass transition temperature (T_g) shall be determined by differential scanning calorimetry (DSC) using ASTM D6604, following the requirements of 8-300.4.1(d). The reported resin T_g shall be no less than the required T_g listed in the Manufacturing Specification and Fabricator's Data Report. The T_g test results must be recorded on the Procedure Specification (Form Q-120), and shall be reported in the Fabricator's Data Report, and used to document the Maximum Allowable Temperature on Form CPV-1.

(d) The Fabricator is responsible for verifying the resin systems structural integrity to withstand 5,000 cycles to design pressure at 250°F (121°C) utilizing a subscale vessel constructed from the selected resin, fiber, and liner materials, and with representative fiber stress levels. After cycle testing, the subscale vessel will be subjected to the leak test in accordance with 8-700.5.8 and the burst test in accordance with 8-700.5.3. This cycle testing is considered an addition to 8-300.4.1(d), to verify the maximum use temperature of the resin/fiber system.

(e) This Case number shall be shown on the Fabricator's Data Report.

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Case 2857

EN 10028-7 and SA-240/SA-240M Austenitic Stainless Steel Plates for Cryogenic Applications

Section XII

Approval Date: May 2, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the following austenitic stainless steel grades of EN 10028-7 and SA-240/SA-240M be used in the construction of Section XII, Modal Appendix 1, Article 4 and Modal Appendix 3, Article 1 tanks using their 1% offset yield strength?

- (a) EN 10028-7
 - (1) X2CrNi18-9
 - (2) X2CrNiMo17-12-2
 - (3) X2CrNiMoN17-11-2
 - (4) X2CrNiMoN17-13-3
 - (5) X2CrNi18-10
 - (6) X5CrNiMo17-12-2
 - (7) X5CrNi18-10
 - (8) X5CrNi19-9
 - (9) X6CrNiTi18-10
- (b) SA-240/SA-240M
 - (1) 304
 - (2) 304L
 - (3) 304LN
 - (4) 304N
 - (5) 316
 - (6) 316L
 - (7) 316LN
 - (8) 321

Reply: It is the opinion of the Committee that the austenitic stainless steel grades of EN 10028-7 and SA-240/SA-240M as described in the Inquiry may be used in the construction of Section XII, Modal Appendix 1, Article 4 and Modal Appendix 3, Article 1 tanks, provided the following requirements are met:

- (a) The thickness of the plates shall not exceed 38 mm (1.5 in.).
- (b) The design temperature shall not exceed 38°C (100°F).
- (c) Tensile and 0.2% and 1% offset yield strength values shall meet the requirements in [Table 1](#) or [Table 1M](#).
- (d) The maximum allowable stress values, *S*, shall be those listed in [Table 2](#) or [Table 2M](#).
- (e) For toughness requirements, the rules of TM-250 shall apply. The EN 10028-7 materials shall be considered equivalent to SA-240/SA-240M materials as shown in [Table 3](#).
- (f) For external pressure design, the EN 10028-7 materials shall be considered equivalent to SA-240/SA-240M materials as shown in [Table 3](#).
- (g) These materials shall be considered P-No. 8 and Group No. 1 materials.
- (h) Welding procedure and performance qualifications shall be conducted in accordance with Section IX.
- (i) The 1% offset yield strength values of the EN 10028-7 and SA-240/SA-240M materials in this Case shall be provided in the material test report.
- (j) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Tensile and Yield Strength Values

SA-240/SA-240M and EN 10028-7 Type/Grade	Minimum Tensile Strength, ksi	Minimum 0.2% Offset Yield Strength, ksi	Minimum 1% Offset Yield Strength, ksi
304	75	30	36
304L	70	25	35
304LN	75	30	45
304N	80	35	45
316	75	30	38
316L	70	25	38
316LN	75	30	46
321	75	30	35
X2CrNi18-9	72	29	35
X2CrNiMo17-12-2	75	32	38
X2CrNiMoN17-11-2	84	41	46
X2CrNiMoN17-13-3	84	41	46
X2CrNi18-10	80	39	45
X5CrNi18-10	75	31	36
X5CrNiMo17-12-2	75	32	38
X5CrNi19-9	80	39	45
X6CrNiTi18-10	72	29	35

Table 1M
Tensile and Yield Strength Values

SA-240/SA-240M and EN 10028-7 Type/Grade	Minimum Tensile Strength, MPa	Minimum 0.2% Offset Yield Strength, MPa	Minimum 1% Offset Yield Strength, MPa
304	515	205	250
304L	485	170	240
304LN	515	205	310
304N	550	240	310
316	515	205	260
316L	485	170	260
316LN	515	205	320
321	515	205	240
X2CrNi18-9	500	200	240
X2CrNiMo17-12-2	520	220	260
X2CrNiMoN17-11-2	580	280	320
X2CrNiMoN17-13-3	580	280	320
X2CrNi18-10	550	270	310
X5CrNi18-10	520	210	250
X5CrNiMo17-12-2	520	220	260
X5CrNi19-9	550	270	310
X6CrNiTi18-10	500	200	240

Table 2
Maximum Allowable Stress Values in Tension

SA-240/SA-240M and EN 10028-7 Type/Grade	Maximum Allowable Stress for Metal Temperature Not Exceeding 100°F, ksi
304	21.4
304L	20.0
304LN	21.4
304N	22.9
316	21.4
316L	20.0
316LN	21.4
321	21.4
X2CrNi18-9	20.6
X2CrNiMo17-12-2	21.4
X2CrNiMoN17-11-2	24.0
X2CrNiMoN17-13-3	24.0
X2CrNi18-10	22.9
X5CrNi18-10	21.4
X5CrNiMo17-12-2	21.4
X5CrNi19-9	22.9
X6CrNiTi18-10	20.6

Table 3
**Equivalent Grades Between EN 10028-7 and SA-240/
SA-240M for Toughness Rules and External Pressure**

EN 10028-7 Grades	SA-240/SA-240M Types
X2CrNi18-9	304L
X2CrNiMo17-12-2	316L
X2CrNiMoN17-11-2, X2CrNiMoN17-13-3	316LN
X2CrNi18-10	304LN
X5CrNi18-10	304
X5CrNiMo17-12-2	316
X5CrNi19-9	304N
X6CrNiTi18-10	321

Table 2M
Maximum Allowable Stress Values in Tension

SA-240/SA-240M and EN 10028-7 Type/Grade	Maximum Allowable Stress for Metal Temperature Not Exceeding 38°C, MPa
304	147.1
304L	138.6
304LN	147.1
304N	157.1
316	147.1
316L	138.6
316LN	147.1
321	147.1
X2CrNi18-9	142.9
X2CrNiMo17-12-2	148.6
X2CrNiMoN17-11-2	165.7
X2CrNiMoN17-13-3	165.7
X2CrNi18-10	157.1
X5CrNi18-10	148.6
X5CrNiMo17-12-2	148.6
X5CrNi19-9	157.1
X6CrNiTi18-10	142.9

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Case 2859

Annealed Copper SB-152, UNS C10100, O25 Temper

Section VIII, Division 1

Approval Date: June 17, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may annealed copper SB-152, UNS C10100, O25 temper be used in welded and nonwelded construction of Section VIII, Division 1 pressure vessels up to a design temperature of 100°F (38°C)?

Reply: It is the opinion of the Committee that annealed copper SB-152, UNS C10100, O25 temper may be used in welded and nonwelded construction of Section VIII, Division 1 pressure vessels up to a design temperature of 100°F (38°C), provided the following requirements are met:

(a) All rules of Section VIII, Division 1 applicable to Part UNF for copper alloys shall apply.

(b) The following values listed in Section II, Part D for SB-152, UNS C10200, O25 temper material shall be used:

(1) yield strength: Table Y-1

(2) tensile strength: Table U

(3) allowable stresses: Table 1B

(c) The material shall be considered as P-No. 31.

(d) For external pressure design, use Section II, Part D, Subpart 3, Figure NFC-1.

(e) The following values listed in Section II, Part D for UNS C10200 shall be used:

(1) thermal expansion: Table TE-3

(2) modulus of elasticity: Table TM-3

(3) Poisson's ratio and density: Table PRD

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2860

Use of UNS S82012 and S82031 Duplex Stainless Steel Plate, Sheet, and Strip in the Manufacture of Part HLW Water Heaters and Storage Tanks

Section IV

Approval Date: September 1, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S82012 and S82031 duplex stainless steel in SA-240/SA-240M plate, sheet, and strip be used in the welded construction of Section IV, Part HLW unlined water heaters and storage tanks?

Reply: It is the opinion of the Committee that UNS S82012 and S82031 duplex stainless steel in SA-240/SA-240M plate, sheet, and strip may be used in the welded construction of Section IV, Part HLW unlined water heaters and storage tanks, provided the following requirements are met:

(a) Material thickness shall not exceed 0.187 in. (5 mm).

(b) The allowable stress shall be as listed in [Tables 1](#) and [1M](#).

(c) Welding procedure and performance qualification shall be conducted in accordance with Section IX. These materials shall be considered P-No. 10H, Group 1.

(d) For external pressure Section II, Part D, Subpart 3, Figure HA-5 shall be used.

(e) All other requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

NOTE: These materials may utilize the minimum thickness exceptions of HF-301.1(c) up to 160 psi.

Table 1
Maximum Allowable Stress Values for SA-240/SA-240M Plate, Sheet, and Strip

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	UNS S82012	UNS S82031
100	25.4	25.4
200	24.0	23.5
300	22.6	22.2
400	22.0	21.6
500	21.9	21.4

Table 1M
Maximum Allowable Stress Values for SA-240/SA-240M Plate, Sheet, and Strip

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	UNS S82012	UNS S82031
40	175	175
100	164	161
150	156	153
200	152	149
250	151	148
275 [Note (1)]	151	148

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

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Case 2861

Use of UNS S82012 and S82031 Duplex Stainless Steel Plate, Sheet, and Strip

Section IV

Approval Date: September 1, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S82012 and S82031 duplex stainless steel in SA-240/SA-240M plate, sheet, and strip be used in the welded construction of Section IV hot water heating boilers?

Reply: It is the opinion of the Committee that UNS S82012 and S82031 duplex stainless steel in SA-240/SA-240M plate, sheet, and strip may be used in the welded construction of Section IV hot water heating boilers, provided the following requirements are met:

(a) Material thickness shall not exceed 0.187 in. (5 mm).

(b) The allowable stress shall be as listed in [Tables 1](#) and [1M](#).

(c) Welding procedure and performance qualification shall be conducted in accordance with Section IX. These materials shall be considered P-No. 10H, Group 1.

(d) For external pressure Section II, Part D, Subpart 3, Figure HA-5 shall be used.

(e) All other requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

NOTE: These materials may utilize the minimum thickness exceptions of HF-301.1(c) up to 160 psi.

Table 1
Maximum Allowable Stress Values for SA-240/SA-240M Plate, Sheet, and Strip

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	UNS S82012	UNS S82031
100	20.3	20.3
200	19.2	18.8
300	18.1	17.7
400	17.6	17.2
500	17.5	17.1

Table 1M
Maximum Allowable Stress Values for SA-240/SA-240M Plate, Sheet, and Strip

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	UNS S82012	UNS S82031
40	140	140
100	131	129
150	125	122
200	121	119
250	121	118
275 [Note (1)]	121	118

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

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Case 2864-3

9Cr-1Mo-V Material

Section I

Approval Date: August 8, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May seamless tubes, seamless pipes, forged and bored pipes, fittings, forgings, and plates with the chemical composition shown in [Table 1](#), otherwise conforming to the specifications listed in [Table 2](#) for Grade 91, Type 2 be used in Section I construction?

Reply: It is the opinion of the Committee that 9Cr-1Mo-V seamless tubes, seamless pipes, forged and bored pipes, fittings, forgings, and plates with the chemical composition shown in [Table 1](#), otherwise conforming to the specifications listed in [Table 2](#) for Grade 91, Type 2 may be used in Section I construction, provided the following additional requirements are met:

(a) The material shall be austenitized within the temperature range of 1,900°F to 1,975°F (1 040°C to 1 080°C). The rate of cooling from 1,650°F to 900°F (900°C to 482°C) shall be no slower than 9°F/min (5°C/min).

(b) The maximum allowable stress values shall be those shown in [Table 3](#) and [Table 3M](#).

(c) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. This the material shall be considered P-No. 15E, Group 1.

(d) For PWHT, the material shall be considered P-No. 15E, Group 1.

(e) Cold-forming rules for Grade P91 in PG-20 shall apply.

(f) Weld strength reduction factors for the creep strength-enhanced ferritic (CSEF) steel group in Table PG-26 shall apply.

(g) Lead (Pb) content shall be measured and reported.

(h) The materials shall be marked with this Case number.

(i) This Case number shall be shown on the Manufacturer's Data Report Form.

Table 1
Chemical Requirements

Element	Composition Limit, %
Carbon	0.08–0.12
Manganese	0.30–0.50
Phosphorous, max.	0.020
Sulfur, max.	0.005
Silicon	0.20–0.40
Chromium	8.00–9.50
Molybdenum	0.85–1.05
Tungsten, max.	0.05
Nickel, max.	0.20
Vanadium	0.18–0.25
Columbium	0.06–0.10
Nitrogen	0.035–0.070
Copper, max.	0.10
Aluminum, max.	0.020
Boron, max.	0.001
Titanium, max.	0.01
Zirconium, max.	0.01
Arsenic, max.	0.010
Tin, max.	0.010
Antimony, max.	0.003
N/Al ratio, min.	4.0

Table 2
Specifications

Material	Specification
Fittings	SA-234/SA-234M
Forged and bored pipe	SA-369/SA-369M
Forgings	SA-182/SA-182M, SA-336/SA-336M
Plate	SA-387/SA-387M
Seamless pipe	SA-335/SA-335M
Seamless tube	SA-213/SA-213M

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
1,000	16.3 [Note (1)], 16.7 [Note (2)]
1,050	12.6
1,100	9.1
1,150	6.1
1,200	3.7

GENERAL NOTE: These values are calculated from time-dependent properties unless otherwise noted.

NOTES:

- (1) For SA-369/SA-369M, SA-387/SA-387M, SA-335/SA-335M, and SA-213/SA-213M. This value is calculated from time-independent properties.
- (2) For SA-234/SA-234M, SA-182/SA-182M, and SA-336/SA-336M.

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
550	102
575	78.2
600	57.6
625	39.2
650 [Note (1)]	25.1

GENERAL NOTE: These values are calculated from time-dependent properties.

NOTE: (1) The value provided at 650°C is for interpolation use only. The maximum use temperature is 649°C.

Case 2865

Material of Minor Attachments Welded Directly to Pressure Parts Made of Q&T Steels Covered by Table UHT-23 of Division 1 and Table 3-A.2 of Division 2

Section VIII, Division 1; Section VIII, Division 2

Approval Date: September 30, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May minor attachments be excluded from the requirements of UHT-28(a) of Division 1 and 3.5.3.1 of Division 2 and may material given in UG-4(b) of Division 1 and 4.2.5.6(c) of Division 2 be used for minor attachments welded directly to pressure parts made of quenched and tempered (Q&T) steels?

Reply: It is the opinion of the Committee that minor attachments may be excluded from the requirements of UHT-28(a) of Division 1 and 3.5.3.1 of Division 2 and non-ASME certified minor attachments made from material that does not conform to a material specification permitted in Division 1 and Division 2 may be used for minor attachments, provided the following requirements are met:

(a) Minor attachments are parts of small size, less than or equal to 0.375 in. (10 mm) thick or 5 in.³ (82 cm³) in volume, that carry no load or an insignificant load such that a stress calculation in designer's judgment is not required, e.g., nameplates, insulation supports, and locating lugs.

(b) The specified minimum tensile strength of Q&T steels shall be less than or equal to 100 ksi (690 MPa).

(c) The specified minimum yield strength of minor attachments shall be within +20% and -60% of that of the material to which they are attached.

(d) If the minor attachment is welded in the area less than $2.5\sqrt{R_m t}$ (where R_m = mean radius of shell, t = thickness of shell) from any gross structural discontinuity, the stress evaluation in accordance with Division 2, Part 5 shall be performed.

(e) The effect of differential thermal expansion shall be considered when the thermal expansion coefficient of the minor attachment differs from that of the pressure part to which it is attached.

(f) Welding materials with the equivalent room-temperature tensile strength as that of Q&T steels shall be used.

(g) The materials for minor attachments shall be proven to be of weldable quality to the requirements in UW-5(b), Division 1 or 3.2.1.3, Division 2.

(h) The materials for minor attachments shall be compatible insofar as welding is concerned with that to which the attachment is to be made.

(i) If the continuous fillet weld is used, the leg dimension of fillet weld shall not be less than $0.25t$ (t = thickness of minor attachment).

(j) The welds shall be postweld heat treated when required by UHT-56 for Division 1 or by Part 6 for Division 2.

(k) This Case number shall be shown in the documentation and on the Manufacturer's Data Report.

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Case 2866

Pin Brazing

Section IX

Approval Date: September 30, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a brazing procedure specification (BPS) be qualified using pin brazing for attaching copper/copper alloy electrical connectors to carbon steel P-No. 101 (limited to those designated P-No. 1 for welding) pressure-retaining piping and components for applications such as cathodic protection, grounding, and nonstructural electrical connections?

Reply: It is the opinion of the Committee that a BPS may be qualified for pin brazing¹ attachments, provided the following conditions are met:

(a) Brazing Procedure Specification (BPS) Qualification

(1) The BPS shall be qualified by performance of ten pin braze tests using the same equipment, connector type (size, shape, and material), and position as will be used in

production. The pin brazing equipment shall be completely automatic except for starting. Any change to the listed variables requires requalification.

(2) Each of the ten brazed connections shall be tested by bending or hammering until the original brazed connection has been bent by at least 45 deg.

(3) In order to pass the test(s), each of the ten brazed connections shall show no more than 50% visible separation or fracture after bending.

(b) Brazing Operator Performance Qualification. Each brazing operator who prepares acceptable BPS qualifications is thereby qualified under the essential variables of QB-351.2. Alternatively, each brazing operator shall successfully pin braze five samples meeting the acceptance criteria for BPS qualification.

(c) This Case number shall be identified in the Manufacturer's Data Report.

¹ *pin brazing:* an automatic brazing process that uses heat from resistance to electric current at the interface between the pin capsule and the workpiece, and then an arc between the pin capsule and the outside surface of the electrical connector to melt the pin capsule that contains brazing filler metal.

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Case 2867-3

Use of Sintered Silicon Carbide (S-SiC) for Pressure Boundary Parts for Frame-and-Plate-Type Pressure Vessels

Section VIII, Division 1

Approval Date: December 7, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may sintered silicon carbide be used for elements in a Section VIII, Division 1 frame-and-plate-type pressure vessel?

Reply: It is the opinion of the Committee that sintered silicon carbide may be used for elements of a Section VIII, Division 1 frame-and-plate-type pressure vessel, provided the following requirements are met:

(a) Plate-and-frame-type vessels that contain sintered silicon carbide plate elements shall be constructed in accordance with the other rules in Section VIII, Division 1. Vessels designated as lethal service, stamped UM, or vessels mass-produced according to Mandatory Appendix 35 shall not be constructed in accordance with this Case.

(b) Sintered silicon carbide pressure vessels and vessel parts are limited to frame-and-plate-type vessels. The vessel shall consist of one or more sintered silicon carbide pressure boundary plate-type modules composed of silicon carbide plates that, after sinter-bonding, form internal passageways through which pressurized fluids will pass. Other plates used for providing process fluid to or for cooling of the silicon carbide modules may also be part of the vessel. Components interconnecting plates may be metallic or parts made from sintered silicon carbide shapes designed and manufactured in accordance with these rules.

(c) Sintered silicon carbide pressure modules and parts shall be limited to:

(1) maximum allowable working pressure: 400 psi (27.2 MPa)

(2) minimum design temperature: -76°F (-60°C)

(3) maximum design temperature: 482°F (250°C)

(d) *Terminology*

burst pressure test: an experimental hydrostatic pressure test used to obtain the failure pressure data for a defined silicon carbide module or part.

green part: a formed part of compacted ceramic powder of low density and low strength prior to sintering and densification.

module number: a unique identification number associated with each sinter-bonded silicon carbide module or parts produced.

powder batch: that quantity of raw materials (silicon carbide powder and sintering agent powders) prepared and blended in a date-specific operation for certified production of sintered silicon carbide modules and parts.

powder batch number: a unique identification number associated with a given batch of raw materials prepared for production.

raw materials: silicon carbide powders suitable for fabrication and sintering.

silicon carbide pressure vessel: a pressure vessel constructed of certified sintered silicon carbide modules and parts.

sinter, sinter-bond: to agglomerate, densify, bond, and strengthen a porous ceramic powder compact into a dense, strongly bonded, high-strength body by the action of heat.

sinter lot: that quantity (one or more) of certified silicon carbide modules or parts produced in a single sintering operation from a single powder batch that meets established specifications for raw material properties, process control, sintered material properties, and module performance.

sinter lot number: a unique identification number associated with a given lot of silicon carbide modules or parts produced in a single sintering operation.

sintered silicon carbide material: a high-density alpha-phase silicon carbide component that has been sintered in an inert atmosphere at a temperature in excess of 3,630°F (2,000°C) to a density not less than 1.79 oz/in.³ (3.10 g/cc).

sintering agent: an elemental metal or metal carbide powder added to a silicon carbide powder mix to produce densification, bonding, and high strength during the high temperature sintering process.

(e) *Raw Material Control and Certification.* Sintered silicon carbide material used for pressure parts shall be manufactured from powder batches that shall not exceed 3,300 lb (1,500 kg). This material shall be qualified by forming, sintering, and testing of test pieces representing each batch.

(1) Each batch shall be certified by the module manufacturer of the material to meet the chemical analysis requirements of [Table 1](#). This analysis shall be performed directly on sintered test pieces described in [Table 2](#).

(2) Test pieces shall be shaped to the dimensions specified in [Table 2](#) using the same forming methods and processes as those to be used for production. The test pieces shall be sintered per the module producer-defined sintering process. Sintered test pieces shall meet the requirements of [Table 2](#).

(3) All silicon carbide material shall be certified by the module manufacturer to meet the property requirements in [Tables 1](#) and [2](#) and all other requirements in this Case. The manufacturer of certified material shall prepare and maintain a written record for each production lot that includes the information and test data specified in (1). Sintered SiC material used in the manufacturing of the modules and parts shall be identified by powder batch number and documented on [Form CMQ](#), Certified Material Qualification, by the module manufacturer.

(f) Pressure vessel modules and containment design shall be as follows:

(1) A vessel assembly consists of a number of stacked silicon carbide pressure modules alternated with other fluid-handling modules and cooling modules that are contained by bolts and end plates of sufficient size and stiffness that the pressure loads are contained by that assembly. With the exception of the sintered plate modules and parts described in this Case, all of the remaining pressure containing components that comprise the completed vessel shall be in accordance with Section VIII, Division 1.

(2) Design of the SiC modules and parts shall be based on hydrostatic burst pressure testing by the Manufacturer to failure of a minimum of five SiC modules or five parts. These modules shall be full-size SiC modules or parts fabricated, finished, and sinter-bonded per the Manufacturer's module specification, which shall include dimensional tolerances, surface finish requirements, geometric features, and tolerances. Any allowance specified by the designer for corrosion or other service-related thinning mechanism shall be taken into account when making up the test modules and parts.

(3) The results of these pressure tests shall be used to establish the maximum allowable working pressure ($P_{\max 99\%}$) for the modules which shall be that pressure which provides probability of failure (POF) not greater than 1% ($\text{POF} \leq 1\%$; reliability $\geq 99\%$) at 95% confidence level using a Weibull statistical analysis as represented by a single-sided confidence interval. That

analysis for the Weibull-shape parameter and the Weibull-scale parameter shall be done per Mandatory Appendix I, [I-2](#) or [I-3](#), and the calculations of the 1% POF (99% reliability) maximum allowable working pressure ($P_{\max 99\%}$) value shall be done per Mandatory Appendix I, [I-4](#). A larger number of tests than the minimum may be done in order to produce a tighter statistical confidence band for the Weibull analysis, which may result in a higher maximum allowable working pressure.

(4) Commercially available software may be used for this analysis as described in [Mandatory Appendix I](#).

(5) Except as modified herein, burst testing shall be conducted in accordance with the provisions of UG-101, including preparation of a burst test report.

(g) Requirements for fabrication are as follows:

(1) The manufacture of silicon carbide modules and the fabrication of other vessel parts shall conform to the requirements of Section VIII, Division 1 and to the specific requirements in this Case.

(2) The Manufacturer shall be responsible for the quality of the materials, processes, and personnel used by their organization and shall conduct tests of the processes to ensure that materials and assemblies comply with the requirements of this Case.

(h) SiC pressure modules and parts shall be manufactured as follows:

(1) *SiC Plates.* Certified silicon carbide powder batches with sintering agents shall be used as the raw material for forming the green modules and parts.

(2) The fabrication and forming of the green modules and parts prior to sintering shall be made using one of the following processes: isostatic pressure, extrusion, injection, pressing, or any process using dry, wet, or plastic forming. One or two formed plates shall be used to form a module with internal passageways, inlets, and outlets. Modules and parts shall be sintered in argon at low pressure at a temperature higher than 3,630°F (2000°C) to produce silicon carbide modules with the required alpha phase content. The ramp-up rate and sinter hold time shall be chosen in such a way that the plates will sinter uniformly to the required bulk density of 1.79 oz/in.³ (3.10 g/cc) minimum.

(3) Sintered silicon carbide modules and parts may be cut, machined, ground, and finished to meet the Manufacturer's dimensional tolerances, surface finish requirements, geometric features and tolerances given in the engineering design and this Case.

(4) Surface finish flaws in silicon carbide plates or parts shall be removed following the manufacturer's standard practices provided dimensional requirements are met.

(5) The SiC pressure modules shall be fitted with metal or silicon carbide parts for fluid inlet and outlet fluid flow, using perfluoromer gaskets or any other gasket material suitable for the use with the chemicals flowing into and from the modules.

**FORM CMQ CERTIFIED MATERIAL QUALIFICATION
(Used in Sintered Silicon Carbide Vessels)**

Material Manufacturer: _____
Certified Material Qualification Number _____ Date _____
Powder Batch Number _____
Sinter Lot Number _____ Production Date _____
Qualification of certified material specification (CMS) no. _____
Raw material manufacturer _____

Sintered Silicon Carbide Material Characteristics

Percentage phase and chemical composition

Alpha phase silicon carbide (x-ray diffraction): _____
Free carbon (ISO 21068-2): _____
Oxygen (ISO 21068-2): _____
Iron (ISO 21068-2): _____
Aluminum (ISO 21068-2): _____

Sintering agent and percentage by weight:

Bulk density of test pieces: _____ Grain size: _____ (Based on CMQ No:) _____

Biaxial flexure strength, MPa

Average biaxial flexure strength: _____ Test date: _____

We certify that the statements made in this report are correct and that the material test data reported above was obtained in accordance with the requirements of ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1, Code Case 2867.

Materials manufacturer: _____

By: _____ Date: _____

(i) Examination and Testing of Modules and Completed Vessel

(1) Sintered Silicon Carbide Modules

(-a) Each silicon carbide module shall be examined by the Manufacturer for dimensional tolerances and surface finish per requirements established by the Manufacturer. The minimum thickness of any module shall not be less than that of the thinnest module used for the design burst test in [\(f\)\(2\)](#) plus the corrosion allowance. A module or part that fails the dimensional or surface finish examination may be refinished to meet the requirements, provided the required wall thickness remains after such finishing. Modules and parts shall be accepted for finish and dimensions before proceeding to integrity pressure testing.

(-b) The hydrostatic integrity pressure test and the gas leak test defined in [\(k\)](#) shall be conducted by the Manufacturer to verify the structural integrity and pressure tightness of each silicon carbide pressure modules.

(2) Vessel Assembly. The hydrostatic test in accordance with UG-99 shall be conducted by the Manufacturer to establish the pressure tightness of the assembled vessel consisting of individual sintered silicon carbide modules, fluid-handling modules, and cooling module as necessary to make the vessel function as required. If an assembled vessel fails the hydrostatic pressure test, it shall be rejected or repaired.

(j) The Manufacturer shall prepare a written examination procedure in accordance with the requirements of Section V, Article 9, Visual Examination. Personnel who perform visual examination shall be qualified and certified in accordance with the employer's written practice. SNT-TC-1A or ASNT CP-189 shall be used as a guideline for employers to establish their written practice. National or international central certification programs, such as the ASNT Central Certification Program (ACCP), may be used to fulfill the examination and demonstration requirements of the employer's written practice. The following visual examinations shall be performed:

(1) The exterior surfaces of each silicon carbide module shall be visually inspected and shall exhibit no surface crack longer than 0.004 in. (0.1 mm) after pressure testing. A module that fails the visual examination shall be rejected or repaired following the manufacturer's procedures. Any repaired areas shall be visually re-examined.

(2) The examination shall be documented in accordance with Section V, Article 9, T-990. Documentation showing that the required examinations have been performed and that the results are acceptable shall be made available to the Authorized Inspector.

(k) The following pressure tests shall be conducted after each module and part has been visually examined and found acceptable:

(1) Each module and part shall be hydrostatically tested at ambient temperature at 2.5 times the maximum allowable working pressure before assembly into the

vessel. Any module that fails to reach that pressure or exhibits fracture or cracking shall be rejected.

(2) Each module shall be pneumatically pressure tested at 30% of the maximum allowable working pressure at ambient temperature and held for 20 min during which time the pressure shall not drop more than 3 psi (0.2 bar). Modules or parts exhibiting pressure drop exceeding this limit shall be rejected or repaired following the manufacturer's procedures and retested beginning with the visual examination specified in [\(1\)](#) followed by the pressure integrity test described in [\(1\)](#).

(3) The assembled frame-and-plate vessel shall be hydrostatically tested in accordance with UG-99.

(l) The following documentation is required:

(1) Form CMQ, Certified Material Qualification showing the following:

(-a) module manufacturer's name, powder batch number, sinter lot number, and production date.

(-b) batch- and sinter-lot-specific powder phase content and chemical analysis of sintered test plates with test date per [Table 1](#).

(-c) sinter-lot-specific bulk density results for the test plates from each powder batch per [Table 2](#) with test date.

(-d) sinter-lot-specific biaxial flexure strength test plate results data for each powder batch data per [Table 2](#) with test date.

(2) Sintered Silicon Carbide Modules

(-a) manufacturer, module number, and production date

(-b) sintered grain size as required by [Table 2](#)

(-c) pass/fail visual examination results per

[\(j\)\(1\)](#)

(-d) pass/fail results of the integrity pressure test per [\(k\)\(1\)](#)

(-e) pass/fail results of the pressure leak test per [\(k\)\(2\)](#) for each silicon carbide module.

(3) Vessel Assembly Report. Pass/fail results of the hydrostatic test for each assembled vessel.

(m) The module manufacturer shall certify that the material supplied has been manufactured, inspected, sampled, and tested in accordance with the requirements of this Case and that the results of chemical analysis, physical, mechanical, and other tests meet the requirements of this Case.

(n) The Manufacturer shall maintain records of the procedures employed in fabricating and producing silicon carbide modules and parts. The Manufacturer shall also maintain records of the tests and their results by which the silicon carbide powder batches and sinter lots were qualified for each module. The Manufacturer shall maintain the records of design data calculations, proof test report, certified material test reports, visual examination results, the procedure specifications that detail the materials used, fabrication procedures, integrity pressure testing and quality control records. All records shall be dated and

shall be certified by the Manufacturer and made available to the Authorized Inspector. The Manufacturer shall keep these records on file for at least 3 yr after production of a vessel.

(o) This Case number shall be marked on the documentation required by (m) and on the Manufacturer's Data Report.

(p) *References*

- [1] Recommended Practice No. SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing
 [2] ASNT CP-189, Standard for Qualification and Certification of Nondestructive Testing Personnel
 [3] ASTM C373, Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired White-ware Products
 [4] ASTM C1499, Monotonic Equibiaxial Flexural Strength of Advanced Ceramics at Ambient Temperature

[5] ASTM E112, Standard Test Methods for Determining Average Grain Size

[6] ASTM E1382, Standard Test Methods for Determining Average Grain Size Using Semiautomatic and Automatic Image Analysis

[7] ISO 21068-1, Chemical analysis of silicon-carbide-containing raw materials and refractory products — Part 1: General information and sample preparation

[8] ISO 21068-2, Chemical analysis of silicon-carbide-containing raw materials and refractory products — Part 2: Determination of loss on ignition, total carbon, free carbon and silicon carbide, total and free silica and total and free silicon

[9] ISO 21068-3, Chemical analysis of silicon-carbide-containing raw materials and refractory products — Part 3: Determination of nitrogen, oxygen and metallic and oxidic constituents

Table 1
Requirements for Sintered Silicon Carbide Material

Element	Limit, wt %	Test Method
Alpha phase silicon carbide	98.5% minimum	X-ray diffraction
Free carbon	1.5% maximum	ISO 21068-2:2008
Oxygen	2% maximum	ISO 21068-2:2008
Iron	500 ppm maximum	ISO 21068-3:2008
Aluminum	1,000 ppm maximum	ISO 21068-2:2008

GENERAL NOTES:

- (a) A batch of raw material powder is defined by a blend of alpha-phase SiC powder mixed with the sintering agents; no other SiC phase type shall be permitted.
 (b) The sintering agent shall be an elemental metal or a metal carbide compound. Metal oxide compounds are prohibited. The maximum sintering agent addition shall be 1% by weight.

Table 2
Required Properties and Test Methods for Sintered Silicon Carbide Test Plates for Material Certification

Property	Limit	Test Method	Test Count per Batch	Test Specimen Description
Bulk density by Archimedes Immersion at 68°F ± 2°F (20°C ± 1°C)	1.79 oz/in. ³ (3.10 g/cc) minimum	ASTM C373	One test specimen per sinter lot, tested by direct immersion	Any specimen size
Biaxial flexure strength at 68°F ± 4°F (20°C ± 2°C)	Average > 50,800 psi (350 MPa); 90% of samples above 39,900 psi (275 MPa)	ASTM C1499	20 tests for each powder batch	0.157 in. (4 mm) thick by 2.6 in. (66 mm) in diameter, tested using an as-fired surface
Sintered average grain size	Less than 10 μm	ASTM E112-2013 or ASTM E1382-97 (R2013)	First sinter lot and one every five sinter lots	Any specimen size

MANDATORY APPENDIX I

EXAMPLE WEIBULL STATISTICAL CALCULATION OF THE MAXIMUM ALLOWABLE WORKING PRESSURE FOR THE SILICON CARBIDE MODULES

I-1 WEIBULL DISTRIBUTION ANALYSIS FOR RELIABILITY AND PROBABILITY OF FAILURE

Weibull distribution analysis is a widely used statistical tool for characterizing experimental data sets with skewed/(extreme value) distributions that are not well modeled with normal/Gaussian distribution statistics. Based on that capability, Weibull analysis is also used for reliability/survival analysis and failure prediction based on experimental data. 1, 2, 3

The four statistical functions used in distribution analysis are the probability density function, the probability cumulative distribution function, the failure probability function, and the reliability/survivability function. In Weibull analysis, these functions are defined in two forms: a three-parameter form and a two-parameter form. The two-parameter Weibull analysis assumes that the threshold parameter, μ , is zero and only uses the characteristic scale parameter, S_c , and the shape parameter, m . The three-parameter Weibull analysis uses three parameters in the equations: a characteristic scale parameter, S_c ; a shape parameter, m ; and a threshold/location parameter, μ . The Weibull analysis methods described in this Appendix are based on the analysis procedures in Section III, Division 5, Mandatory Appendix HHA-II.³

¹ *The Weibull Analysis Handbook*, Bryan Dodson, ASQ Quality Press, Milwaukee, WI, 2006.

² J.B. Quinn, G. D. Quinn, "A Practical and Systematic Review of Weibull Statistics for Reporting Strengths of Dental Materials," *Dental Materials*, Volume 26, Issue 2 (February 2010): 135-147.

³ ASME BPVC, Section III, Division 5, Mandatory Appendix HHA-II, Article HHA-II-3000, Detailed Requirements for Derivation of the Material Data Sheet — As-Manufactured Properties.

I-2 WEIBULL TWO-PARAMETER ANALYSIS FOR SIMPLE ASSESSMENT OF MAXIMUM ALLOWABLE WORKING PRESSURE

The Weibull probability density function $f(x)$ of the burst pressure test data is defined from the measured burst pressure values, x , using the two-parameter Weibull distribution in eq. (1).

$$f\left(x\right) = \left(\frac{x}{S_c}\right)^{m-1} \cdot \frac{m}{S_c} \cdot \exp\left[-\left(\frac{x}{S_c}\right)^m\right] \quad (1)$$

where $x > 0$

The two-parameter Weibull probability distribution function [eq. (2)] is also the failure probability $p(x)$ function.

$$p\left(x\right) = \int_0^x f\left(x'\right) \cdot dx' = 1 - \exp\left[-\left(\frac{x}{S_c}\right)^m\right] \quad (2)$$

where $x > 0$

The two-parameter reliability/survival function $L(x)$ is defined in eq. (3).

$$L\left(x\right) = 1 - p\left(x\right) = \exp\left[-\left(\frac{x}{S_c}\right)^m\right] \quad (3)$$

where $x > 0$

In all of these equations, the Weibull parameter terms are:

m = the shape parameter

S_c = the characteristic scale/strength parameter/value

The m and S_c values are determined from the experimental data using a least squares fit of the linearized eq. (4) that corresponds to linear eq. (5).

$$\ln\{-\ln[L(x)]\} = + m \cdot \ln(x) - m \cdot \ln(S_c) \quad (4)$$

$$y(x) = a \cdot x + b \quad (5)$$

The burst test pressure data values are arranged in a monotonically increasing order. Each of the measured burst pressure values is given a probability of survival in accordance with eq. (6).

$$L_k = 1 - \frac{k}{n + 1} \tag{6}$$

where

$$k = 1, \dots, n$$

Applying the least squares straight line fit to the burst pressure data, one obtains estimated values of m^* and S_c^* for the true Weibull parameters m and S_c . These estimated values are approximations whose precision depends on the number and scope of burst pressure tests done. Greater precision is achieved with more test data (i.e., 5 minimum, >10 recommended).

For the maximum allowable working pressure determination, the Weibull parameters corresponding to a confidence level (γ) of 95% are to be used (lower limit of the one-sided confidence interval).

These 95% confidence values $m_{95\%}$ and $S_{c95\%}$ are determined from eqs. (7) and (8), where the correction factors t and t' are determined using Figures I-2-1 and I-2-2 and the sample size (number of data points).

$$m_{95\%} = \frac{m^*}{t(n; 0.95)} \tag{7}$$

$$S_{c95\%} = S_c^* \times \exp[-t'(n; 0.95)/m^*] \tag{8}$$

Weibull analysis software programs and modules are common components in commercial statistical software packages and are recommended for reliable and easy analysis of the data to determine the Weibull parameters for a given data set.

I-3 WEIBULL THREE-PARAMETER ANALYSIS FOR FULL ASSESSMENT OF MAXIMUM ALLOWABLE WORKING PRESSURE

If the lower limit for the bursting pressure is non-zero, then the two-parameter Weibull distribution will not accurately fit the left-hand side of the data distribution. This is commonly seen in a downward curve of the data on the left-hand side of the data distribution log plot. In this case, the three-parameter Weibull analysis should be used to accurately characterize the data. The only difference in the baseline function equations is the term x is replaced with the term $(x - \mu)$, and x has to be greater than the threshold parameter μ .

The calculation of the estimated values m^* and S_c^* for the three-parameter Weibull analysis is similar to the method described for two-parameter analysis, accounting for the

threshold term μ . However, a maximum likelihood estimator (MLE) function is used to calculate the m^* and S_c^* values rather than a linear least squares fit. The MLE function is also used to calculate the confidence levels for the two Weibull parameters. This method is described in more detail in Section III, Division 5, Mandatory Appendix HHA-II-3200.³ In practical use, Weibull software is the easiest method of calculating $m_{95\%}$, $S_{c95\%}$, and $\mu_{95\%}$ values for three-parameter calculations.

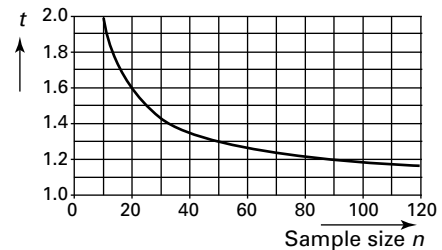
I-4 MAXIMUM ALLOWABLE WORKING PRESSURE BASED ON BURST PRESSURE TESTS

Using the calculated values of $m_{95\%}$, $S_{c95\%}$, and $\mu_{95\%}$ from the burst pressure test data, the maximum (99% reliability = 1% probability of failure) allowable working pressure value ($P_{\max 99\%}$) is calculated from eq. (9):

$$P_{\max 99\%} = \left(S_{c95\%} - \mu_{95\%} \right) \left(-\ln(0.99) \right)^{\frac{1}{m_{95\%}}} \tag{9}$$

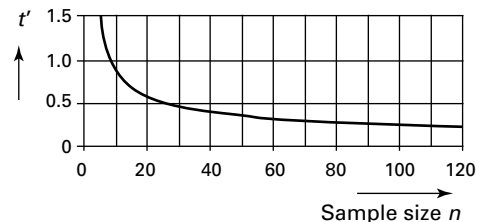
For two-parameter analysis, $\mu_{95\%} = 0$.

Figure I-2-1
Correction Factor t of the Shape Parameter m of Two-Parameter Weibull Distribution



GENERAL NOTE: Confidence level, $\gamma = 0.95$

Figure I-2-2
Correction Factor t' of the Characteristic Value S_c of Two-Parameter Weibull Distribution



GENERAL NOTE: Confidence level, $\gamma = 0.95$

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Case 2868-1
Qualification of Partial-Penetration Groove Welds Using Laser or
Electron Beam Welding (25)

Section I; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX

ANNULLED

March 30, 2025

Reason: No longer needed.

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Case 2869-1

Use of Stainless Steel Material With a Minimum Thickness of 0.0157 in. (0.4 mm) for Hot Water Heating Boilers

(25)

Section IV

Approval Date: December 2, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may stainless steel plate listed in Section II, Part, D Table 6A be used with a minimum thickness of 0.0157 in. (0.4 mm) for the construction of Section IV hot water heating boilers?

Reply: It is the opinion of the Committee that stainless steel plate listed in Section II, Part, D Table 6A with a minimum thickness of 0.0157 in. (0.4 mm) may be

used for the construction of Section IV heating boilers, provided the following requirements are met:

(a) The stainless steel plate is not exposed to primary furnace gases.

(b) Maximum allowable working pressure shall not exceed 45 psi (310 kPa).

(c) The design shall be validated by a proof test in accordance with the requirements of HG-500.

(d) All other applicable parts of Section IV shall apply.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2870-2

Use of Stainless Steel Plate and Tube for Hot Water Heating Boilers

Section IV

Approval Date: January 2, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may stainless steel tube and stainless steel plate listed in Section II, Part D, Table 6A with a thickness less than that permitted in HG-301.2 and HF-301.1, respectively, be used for the construction of Section IV heating boilers?

Reply: It is the opinion of the Committee that stainless steel tube and stainless steel plate listed in Section II, Part D, Table 6A with a thickness less than that permitted in HG-301.2 and HF-301.1, respectively, may be used for the

construction of Section IV heating boilers, provided the following requirements are met:

(a) Minimum wall thickness of tube shall not be less than 0.020 in. (0.5 mm) with an outside diameter not exceeding 0.98 in. (24.9 mm).

(b) Minimum thickness of plate shall not be less than 0.039 in. (1.0 mm).

(c) Maximum allowable working pressure shall not exceed 45 psi (310 kPa).

(d) The design shall be validated by a proof test in accordance with the requirements of HG-500.

(e) All other applicable parts of Section IV shall apply.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2871-1

Use of SA-240/SA-240M, Types 316Ti, 316L, 439, and UNS S43932 With Thickness Less Than $\frac{3}{32}$ in. (2.5 mm)

Section IV

Approval Date: March 21, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-240/SA-240M, types 316Ti, 316L, 439, and UNS S43932 with thickness less than $\frac{3}{32}$ in. (2.5 mm) be used in the construction of Section IV hot water heating boiler in a closed system?

Reply: It is the opinion of the Committee that SA-240/SA-240M, types 316Ti, 316L, 439, and UNS S43932 with thickness less than $\frac{3}{32}$ in. (2.5 mm) may be used in the construction of Section IV hot water heating boiler in a

closed system, provided the following requirements are met:

(a) The operating service shall be limited to closed hot water heating systems at a maximum pressure of 50 psi (350 kPa).

(b) The cylindrical parts of the pressure vessel shall be limited to a maximum of 19 in. (480 mm) outside diameter.

(c) The material thickness shall not be less than 0.0275 in. (0.7 mm) (actual thickness).

(d) The MAWP of the pressure parts shall be established by proof test in accordance with HG-502.3 or HG-503.

(e) All other requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2872

Use of SA-240/SA-240M, Plate Alloy Steel, Grades 304L and 316L With Thickness Less Than $\frac{1}{8}$ in. (3 mm)

Section IV

Approval Date: November 30, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-240/SA-240M, plate alloy steel, grades 304L and 316L with thickness less than $\frac{1}{8}$ in. (3 mm) be used in HLW-302 potable water heater construction?

Reply: It is the opinion of the Committee that SA-240/SA-240M, plate alloy steel, grades 304L and 316L with thickness less than $\frac{1}{8}$ in. (3 mm) may be used in

HLW-302 potable water heater construction for maximum allowable working pressures up to 160 psi (1100 kPa), provided the following requirements are met:

(a) The material thickness shall not be less than 0.059 in. (1.5 mm).

(b) The material shall be limited to headers not exposed to products of combustion.

(c) A burst test shall be performed in accordance with HG-502.3.

(d) All other requirements of Section IV shall apply.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2874

Modular Hot Water Boiler Certified as a Single Boiler

Section IV

Approval Date: November 30, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Section IV Code terminology in Nonmandatory Appendix E, Appendix E-100 defines modular hot water boilers as a grouping of individual boilers installed as a unit and defines the trim requirements in HG-615 and HG-716. Under what conditions is it permitted to certify the assembled boilers as a single boiler?

Reply: It is the opinion of the Committee that modular hot water boilers may be certified as a single boiler, provided the following requirements are met:

(a) Individual modules are documented on a single master data report listing all of the modules.

(b) The assembled modules are provided with a single nameplate stamping.

(c) Individual modules shall be marked in a manner traceable to the assembled boiler nameplate and data report.

(d) The aggregate heating surface of all modules and the combined minimum relief valve capacity shall be stamped on the nameplate.

(e) Supply and return headers shall be constructed in accordance with Section IV and recorded on the Manufacturer's Data Report.

(f) The pressure/altitude gage and thermometer required on each module by HG-615(a)(1) and (a)(2) may be replaced by a single gage and thermometer located on the supply header.

(g) The assembled modular boiler shall be installed without stop valves between modules and shall be provided with a single set of stop valves on the common supply and return headers in accordance with HG-710.2. Flow control valves and circulating pumps may be located in the individual module return lines.

(h) The safety valve(s) required on each module by HG-716(a)(3)(-a) may be replaced by one or more safety valves located on the supply header.

(i) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2875

Use of UNS N08904 (904L) Austenitic Stainless Steel Plate, Sheet, Strip in the Manufacture of Part HLW Water Heaters and Storage Tanks

Section IV

Approval Date: November 30, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS N08904 (904L) austenitic stainless steel in SA-240/SA-240M plate, sheet, and strip be used in the welded construction of Section IV, Part HLW unlined water heaters and storage tanks?

Reply: It is the opinion of the Committee that UNS N08904 (904L) in SA-240/SA-240M plate, sheet, strip may be used in the welded construction of Section IV, Part HLW unlined water heaters and storage tanks, provided the following requirements are met:

(a) The allowable stress shall be as listed in [Tables 1](#) and [1M](#).

(b) Welding procedure and performance qualification shall be conducted in accordance with Section IX. This material shall be considered as P.-No. 45.

(c) For external pressure Section II, Part D, Figure NFN-9 shall be used.

(d) The maximum design temperature shall be 500°F (260°C).

(e) All other requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

NOTE: This material may utilize the minimum thickness exceptions of HF-301.1(c) up to 160 psi (1 100 kPa).

Table 1
Maximum Allowable Stress Values for SA-240/SA-240M Plate, Sheet, Strip

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi, for UNS N08904 (904L)
100	17.8
200	16.7
300	15.1
400	13.9
500	12.7

Table 1M
Maximum Allowable Stress Values for SA-240/SA-240M Plate, Sheet, Strip

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa, for UNS N08904 (904L)
40	123
100	114
150	104
200	96.0
250	88.7
275 [Note (1)]	86.0

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

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Case 2876-1

Allowing Nameplate to Be Placed in Alternate Location Due to Insufficient Space

Section IV

Approval Date: March 21, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the nameplate of a potable water heater be located in a location other than as described in HLW-602.3?

Reply: It is the opinion of the Committee that the nameplate of a potable water heater may be located in a location other than as described in HLW-602.3 when there is not sufficient space on the water heater vessel, provided the following requirements are met:

(a) The nameplate shall be permanently attached and located in a conspicuous location accessible for inspection on the water heater vessel casing or supports.

(b) A Manufacturer's unique identification number shall be permanently and legibly marked in an accessible location on the water heater vessel to provide traceability to the nameplate's serial number. The marking shall be in characters not less than $\frac{5}{32}$ in. (4 mm). Method and control of the applied marking and its traceability shall be described in the QC manual accepted by the Authorized Inspector.

(c) A Manufacturer's unique identification number shall be additionally marked on the nameplate and documented on the Manufacturer's Data Report in the remarks section.

(d) All other requirements of Section IV shall be met.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2877

Welded Austenitic Stainless Steel Condenser and Heat Exchanger Tubes With Textured Surfaces

Section VIII, Division 1

Approval Date: December 12, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May austenitic stainless steel welded tubes in which the external tube surface, internal tube surface, or both internal and external tube surfaces have a modified configuration, otherwise conforming to SA-249/SA-249M be used for welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that austenitic stainless steel welded tubes in which the external tube surface, internal tube surface, or both internal and external tube surfaces have a modified configuration, otherwise conforming to SA-249/SA-249M may be used for welded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The grades applicable to this Case shall be those shown in Table 1.

(b) The maximum nominal diameter is limited to 1.50 in. (38 mm), and the maximum wall thickness is limited to 0.079 in. (2 mm).

(c) For determination of minimum wall thickness on textured tubing, a point-to-point micrometer shall be used. Alternately, tubing shall be supplied with plain ends and all measurements and proof testing taken in the plain end section of the tubing.

(d) The tubing shall be used for heat transfer equipment and shall be a straight length. When the tubing is used with tubesheets, the tubing shall have a plain end with untextured surfaces for the full length inserted within the tubesheet. The untextured surface would need to be both on the I.D. and the O.D.

(e) Proof tests to establish maximum allowable working pressure.

(1) The maximum allowable working pressure of any component part proof tested by this method shall be established by a hydrostatic test to failure by rupture of a full-size sample of such pressure part. The hydrostatic pressure at which rupture occurs shall be determined. Alternatively, the test may be stopped at any pressure

before rupture that will satisfy the requirements for the desired maximum allowable working pressure.

(2) The maximum allowable working pressure, P , psi, (kPa) at test temperature for parts tested under this paragraph shall be computed by one of the following equations:

$$P = \frac{B}{4} \times \frac{S_{\mu}E}{S_{\mu \text{ avg}}}$$

or

$$P = \frac{B}{4} \times \frac{S_{\mu}E}{S_{\mu r}}$$

where

B = bursting test pressure, or hydrostatic test pressure at which the test was stopped

E = efficiency of welded joint, if used (see Table UW-12)

S_{μ} = specified minimum tensile strength at room temperature

$S_{\mu \text{ avg}}$ = average actual tensile strength of test specimens at room temperature

$S_{\mu r}$ = maximum tensile strength of range of specification at room temperature

The maximum allowable working pressure at other temperatures shall be determined per UG-101(k).

(f) External Pressure Design

(1) Test Procedure

(-a) Test three full-size specimens to failure (visible collapse) by external hydrostatic pressure.

(-b) The maximum allowable working pressure, P , shall be determined by

$$P = F \left(\frac{B}{3} \right) \left(\frac{Y_s}{Y_a} \right)$$

where

B = minimum collapse pressure, psi (kPa)

F = factor to adjust for change in strength due to design temperature = S/S_2

S = maximum allowable stress value for the tube material at design temperature, as given in the tables referenced in UG-23 but not to exceed S_2 , psi (kPa)

S_2 = maximum allowable stress value for the tube material at test temperature, as given in the tables referenced in UG-23, psi (kPa)

Y_a = actual average yield strength determined from the untextured length of the three specimens tested at room temperature, psi (kPa)

Y_s = specified minimum yield strength at room temperature, psi (kPa)

(-c) The length of the tube test specimen shall be at minimum, six times the diameter.

(2) *Criteria*

(-a) The design of austenitic stainless alloys textured tubes to this Case shall meet the following requirements:

(-1) Design temperature shall be limited to the maximum temperature listed in Section II, Part D, Table 1A corresponding to the time independent allowable stress, or the maximum temperature shown on the external pressure chart for the corresponding material, whichever is less.

(-2) Tubes shall have external or internal integral texturing or both.

(-3) Dimensions and permissible variations shall be as specified in SA-249/SA-249M.

(-b) Additional requirements for austenitic stainless steel alloy tubes designed to this Case are as follows:

(-1) Outside diameter of the textured tube section shall not exceed the outside diameter of the plain end section.

(-2) Tests shall be done in accordance with the procedures specified in (e) and (f) and witnessed by and subjected to the acceptance of the Inspector.

(-3) For axial compression, use the minimum thickness of the tube.

(g) Allowable stress values to be used are those located in Section II, Part D for SA-249/SA-249M to each corresponding alloy grade.

(h) All other requirements of Section VIII, Division 1 shall be followed.

(i) This Case number and grade or UNS Number shall be marked on the material, and shown on the material test report and Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

**Table 1
Applicable Grades of Steel**

UNS Designation [Note (1)]	Type
S30400	304
S30403	304L
S30451	304N
S30453	304LN
S31600	316
S31603	316L
S31640	316Cb [Note (2)]
S31651	316N
S31653	316LN
S31700	317
S31703	317L
S31725	317LM [Note (2)]

NOTES:

(1) Designation established in accordance with ASTM E527 and SAE J1086.

(2) Common name, not a trademark, widely used and not associated with any one producer.

Case 2878

NDE Level III Personnel Certified Prior to 2004

Section XII

Approval Date: December 22, 2016

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an NDE Level III personnel certified prior to 2004 be qualified under Section XII?

Reply: It is the opinion of the Committee that qualification of NDE Level III personnel certified prior to the 2004 Edition of Section XII may be based on demonstrated

ability, achievement, education, and experience. Such qualification shall be specifically addressed in the written practice. When NDE personnel have been certified in accordance with a written practice based on an edition of SNT TC-1A or CP-189 referenced in TG-130.1, their certification shall be valid until their next scheduled recertification.

This Case number shall be shown on the Manufacturer's Data Report.

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Case 2879

7% Ni Thermo-Mechanical Control Processed Steel Plate for Cryogenic and Ambient Temperature Applications

Section XII

Approval Date: January 10, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May thermo-mechanical control processed (TMCP) 7% Ni-steel plates, meeting the requirements of ASTM A841/A841M-13 Grade G, Class 9, be used for welded construction under the rules of Section XII?

Reply: It is the opinion of the Committee that TMCP 7% Ni-steel plates meeting the requirements of ASTM A841/A841M-13 Grade G, Class 9, may be used for welded construction under the rules of Section XII, provided the following additional requirements are met:

(a) The maximum permitted nominal thickness of plates is 1.5 in. (38 mm).

(b) The maximum allowable stress values for the material shall be those given in [Table 1](#). Welded construction allowable stresses apply only to butt joints.

(c) The design temperature shall not exceed 150°F (65°C).

(d) For external pressure, Figure CS-3 of Section II, Part D, Subpart 3 shall apply.

(e) Moduli of elasticity values shall be those listed in Section II, Part D, Subpart 2, Table TM-1 for Group F.

(f) Separate welding procedure and performance qualifications in accordance with Section IX shall be required for this material.

(g) The minimum tensile strength (UTS) of the reduced tension specimen in accordance with Figure QW-462.1 shall not be less than 100 ksi (690 MPa) or 95 ksi (655 MPa) at room temperature, depending on the welding process and filler metal used in the construction.¹

(h) During fabrication and assembly, other than during welding, the material shall not be exposed to temperatures exceeding the final tempering temperature of 985°F (530°C).

(i) This Case number shall be shown on the Manufacturer's Data Report.

¹ Some nickel-base AWS classification consumables that will usually meet the 100 ksi (690 MPa) or 95 ksi (655 MPa) tensile strength requirements are: F43, SFA-5.11, ENiCrMo-3, UNS W86112; F43, SFA-5.14, ERNiCrMo-3, UNS N96625; F43, SFA-5.11, ENiCrMo-4, UNS W80276; and F43, SFA-5.14, ERNiCrMo-4, UNS N10276.

Table 1
Maximum Allowable Stress Values in Tension for Welded and Nonwelded Construction

Temperature, °F (°C)	Nonwelded Construction, ksi (MPa)	Welded Construction	
		UTS, 100 ksi (690 MPa)	UTS, 95 ksi (655 MPa)
-320 to 150 (-195 to 65)	28.6 (197)	28.6 (197)	27.1 (187)

Case 2880

Use of UNS C69300 Copper-Zinc-Silicon Alloy Rod in the Manufacture of Pressure Parts for Hot Water Heating Boilers and Potable-Water Heaters

Section IV

Approval Date: March 21, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS C69300 copper-zinc-silicon alloy rod meeting the chemical composition and mechanical properties of ASTM B371/B371M be used for threaded bolts and plugs in the construction of hot water heating boilers and potable-water heaters under the rules of Section IV?

Reply: It is the opinion of the Committee that UNS C69300 copper-zinc-silicon alloy rod meeting the chemical composition and mechanical properties of ASTM B371/B371M may be used for threaded bolts and plugs under Section IV, provided the following requirements are met:

(a) Maximum Allowable Working Pressure shall not exceed 160 psi (1 103 kPa).

(b) The maximum water temperature shall be 250°F (121°C).

(c) The maximum allowable stresses shall be as shown in [Table 1](#) and [Table 1M](#).

(d) The chemical requirements shall be as shown in [Table 2](#).

(e) The mechanical requirements shall be as shown in [Table 3](#).

(f) When this material is used for threaded plugs with recessed sockets, the minimum wall thickness shall be 0.19 in. (4.8 mm).

(g) The material shall be used for threaded bolts and plugs.

(h) All other applicable parts of Section IV shall apply.

(i) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stresses

For Temperature Not Exceeding, °F	Table HF-300.2, ksi	Part HLW, ksi
Up to 100	14.0	17.5
150	14.0	17.5
200	14.0	17.5
250	14.0	17.5
300	14.0	17.5
350	14.0	17.5

Table 1M
Maximum Allowable Stresses

For Temperature Not Exceeding, °C	Table HF-300.2, MPa	Part HLW, MPa
Up to 65	96.5	120.7
100	96.5	120.7
125	96.5	120.7
150	96.5	120.7
175	96.5	120.7
200	96.5	120.7

**Table 2
Chemical Requirements**

Copper Alloy UNS No.	Composition, %, Maximum Except as Indicated										
	Cu	Si	Pb	Fe	Sn	Ni	Mn	As	Sb	P	Zn
C69300	73.0 – 79.0	2.7-3.4	0.10	0.10	0.20	0.10	0.10	...	...	0.04-0.15	Remainder

**Table 3
Mechanical Requirements**

Copper Alloy UNS No.	Minimum Tensile Strength		Minimum Yield Strength		Minimum Elongation in 4X Diameter, %
	ksi	MPa	ksi	MPa	
C69300	70	480	30	205	10

Case 2881

ASTM B16 Material in Pressure Boundary of Vessel

Section VIII, Division 1

Approval Date: March 8, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ASTM B16-10 (R2015), UNS C36000, H02 temper rod material be used in the pressure boundary of a Section VIII, Division 1 vessel at maximum design temperature of 375°F (191°C)?

Reply: It is the opinion of the Committee that ASTM B16-10 (R2015), UNS C36000, H02 temper rod material may be used in the pressure boundary of a Section VIII, Division 1 vessel at a maximum design temperature of 375°F (191°C), provided the following requirements are met:

- (a) Part UNF rules for copper alloys apply.
- (b) The maximum working pressure of the vessel shall not exceed 350 psig (2.4 MPa).
- (c) Diameter shall not exceed 1.0 in. (25 mm).
- (d) External pressure design is not permitted.
- (e) Welding is not permitted.
- (f) Maximum allowable stress values shall be those listed in [Tables 1](#) and [1M](#).
- (g) The tensile test requirements of ASTM B16-10 (R2015) are mandatory. The tensile and yield strength values shall be those listed in [Tables 2](#) and [2M](#) and [Tables 3](#) and [3M](#), respectively.
- (h) The material shall be considered P-No. 107 for brazing. The maximum allowable stress values in the brazed condition shall be those listed in [Tables 4](#) and [4M](#).
- (i) The following values shall apply for physical properties:
 - (1) thermal expansion: Section II, Part D, Table TE-3 for brass alloys
 - (2) modulus of elasticity: Section II, Part D, Table TM-3 for UNS C36500
 - (3) Poisson's ratio: 0.31
 - (4) density: 0.307 lb/in.³ (8.50 kg/mm³)
- (j) A representative finished model (of each product size and design) and each lot of the starting rod material (at a number as specified in SB-249) shall be tested for residual stress according to the requirements of ASTM B154-16 or SB-858, and show no signs of cracking.
- (k) Certification according to SB-249 is required.
- (l) Heat identification is required.

(m) This Case number shall be referenced in the documentation and marking of the material and shown in the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for ASTM B16, UNS C36000, H02 Temper

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Material Up to 0.5 in.	Material > 0.5 in. to 1 in. incl.
100	16.3	14.9
150	16.3	14.9
200	16.0	14.9
250	15.9	14.9
300	15.8	14.9
350	10.7	10.7
400 [Note (1)]	5.3	5.3

NOTE: (1) For interpolation only; maximum design temperature is 375°F.

Table 1M
Maximum Allowable Stress Values for ASTM B16, UNS C36000, H02 Temper

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Material Up to 12 mm	Material > 12 mm to 25 mm incl.
40	112	102
65	112	102
100	110	102
125	109	102
150	109	102
175	74.1	74.1
200 [Note (1)]	42.3	42.3

NOTE: (1) For interpolation only; maximum design temperature is 191°C.

Table 2
Tensile Strength Values for ASTM B16, UNS C36000, H02 Temper

For Metal Temperature Not Exceeding, °F	Tensile Strength Values, ksi	
	Material Up to 0.5 in.	Material > 0.5 in. to 1 in. incl.
100	57.0	52.0
150	57.0	52.0
200	57.0	52.0
250	57.0	52.0
300	57.0	52.0
350	57.0	52.0
400	57.0	52.0

GENERAL NOTE: Maximum design temperature is 375°F. Section II, Part D, Subpart 1, Table U, Note (b) applies to these values.

Table 2M
Tensile Strength Values for ASTM B16, UNS C36000, H02 Temper

For Metal Temperature Not Exceeding, °C	Tensile Strength Values, MPa	
	Material Up to 12 mm	Material > 12 mm to 25 mm incl.
40	393	359
65	393	359
100	393	359
125	393	359
150	393	359
175	393	359
200	393	359
225	393	359

GENERAL NOTE: Maximum design temperature is 191°C. Section II, Part D, Subpart 1, Table U, Note (b) applies to these values.

Table 3
Yield Strength Values for ASTM B16, UNS C36000, H02 Temper

For Metal Temperature Not Exceeding, °F	Yield Strength Values, ksi	
	Material Up to 0.5 in.	Material > 0.5 in. to 1 in. incl.
100	25.0	25.0
150	24.4	24.4
200	24.1	24.1
250	23.8	23.8
300	23.7	23.7
350	23.7	23.7
400	23.7	23.7

GENERAL NOTE: Maximum design temperature is 375°F. Section II, Part D, Subpart 1, Table Y-1, Note (b) applies to these values.

Table 3M
Yield Strength Values for ASTM B16, UNS C36000, H02 Temper

For Metal Temperature Not Exceeding, °C	Yield Strength Values, MPa	
	Material Up to 12 mm	Material > 12 mm to 25 mm incl.
40	172	172
65	168	168
100	165	165
125	164	164
150	163	163
175	163	163
200	163	163
225	162	162

GENERAL NOTE: Maximum design temperature is 191°C. Section II, Part D, Subpart 1, Table Y-1, Note (b) applies to these values.

Table 4
Maximum Allowable Stress Values for ASTM B16, UNS C36000, H02 Temper After Brazing

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi, for Material Up to 1 in.
100	13.3
150	12.6
200	12.0
250	11.5
300	11.1
350	10.7
400 [Note (1)]	5.3

NOTE: (1) Data for interpolation only; maximum design temperature is 375°F.

Table 4M
Maximum Allowable Stress Values for ASTM B16, UNS C36000, H02 Temper After Brazing

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa, for Material Up to 25 mm
40	91.1
65	87.0
100	81.9
125	79.1
150	76.7
175	74.1
200 [Note (1)]	22.1

NOTE: (1) Data for interpolation only; maximum design temperature is 191°C.

Case 2882-1

Modular Potable Water Heaters

Section IV

Approval Date: July 14, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may modular water heaters be certified as a single water heater?

Reply: It is the opinion of the Committee that a modular water heater may be certified as a single heater, provided the following requirements are met:

(a) A complete modular water heater shall be documented on a single Manufacturer's Data Report by documenting "Master Data Report" in the Remarks section of the data report.

(b) When individual modules are certified on a single data report, the serial number of each individual module shall be listed in the Remarks section of the master data report, Form HLW-6, with the single data report attached.

(c) The assembled modules shall be provided with a single nameplate stamping for the modular water heater with the aggregate input Btu/hr (kW) noted on the nameplate stamping.

(d) Individual modules shall be marked in a manner traceable to the assembled modular water heater nameplate and Data Report.

(e) Supply (distribution) and cold water return headers shall be constructed in accordance with Section IV and recorded on the Manufacturer's Data Report.

(f) The thermometer required on each module per HLW-820 may be replaced by a single thermometer located on the supply (distribution) header.

(g) The assembled modular water heater shall be installed without stop valves between modules and should be provided with a single set of stop valves on the common supply (distribution or discharge) and return headers in accordance with HLW-805.3. Flow control valves and circulating pumps may be located in the inlet lines of the individual modules.

(h) The safety valve(s) required on each module by HLW-800.1(a) may be replaced by one or more safety valves located on the supply (distribution) header.

(i) No valve of any kind shall be installed between any module heat exchanger and the safety valve.

(j) The bottom drain valve(s) required on each module by HLW-810(a) or (b) may be replaced by one or more bottom drain valve(s) located at the lowest practicable point on the water heater, or at the lowest point on piping connected to the water heater.

(k) All other requirements of Part HLW, Section IV shall apply.

(l) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2883

Pneumatic Testing in Lieu of Hydrostatic Test

(25)

Section IV

Approval Date: April 12, 2017

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an unlined water heater vessel manufactured and stamped in accordance with Section IV be tested pneumatically in lieu of the hydrostatic test required in HLW-505?

Reply: It is the opinion of the Committee that pneumatic testing may be substituted for the hydrostatic test required in HLW-505, provided the following requirements are met:

(a) The water volume of the water heater vessel shall be less than 20 gal (76 L).

(b) The maximum material thickness of any component part shall not exceed $\frac{1}{2}$ in. (12.7 mm). No components of the water heater vessel that will be subject to pneumatic testing may be constructed of cast iron.

(c) The MAWP shall not be greater than 160 psi (1 100 kPa).

(d) The water heater vessel shall be externally cleaned to prevent air bubble adherence while being tested to prevent leaks from being masked.

(e) The pneumatic test shall be conducted with the water heater vessel submerged in water. The minimum water temperature shall be 60°F (16°C). The upper

most portion of the water heater vessel, as oriented in the test tank, shall be a minimum of 6 in. (150 mm) below the surface of the water.

(f) The boiler should be tested in such a manner as to ensure personnel safety from a release of the total internal energy of the vessel.

(g) The required test pressure shall be $1\frac{1}{4}$ times the MAWP.

(h) The pressure in the water heater vessel shall be gradually increased to not more than one-half of the required test pressure. Thereafter, the pressure shall be increased in steps of approximately one-tenth of the required test pressure until the required test pressure has been reached.

(i) A hold time of 5 min shall be maintained on the water heater vessel at the required test pressure. Thorough visual inspection is not required during this stage. The pressure shall then be reduced to the MAWP and maintained at this pressure while a thorough visual inspection for leakage is made with the water heater vessel submerged a minimum of 6 in. (150 mm) below the surface of the water.

(j) Any evidence of air leaking from the vessel indicates failure of the pneumatic pressure test.

(k) The water heater vessel shall meet all other requirements of Section IV.

(l) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2884

Low-Energy Capacitor Discharge Welding

Section IX

Approval Date: April 4, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may low-energy capacitor discharge welding be used without qualification testing?

Reply: It is the opinion of the Committee that low-energy capacitor discharge welding may be used without qualification, provided the following requirements are met:

(a) The energy output is limited to 125 W-sec, and the minimum thickness of the material to which the attachment is made is greater than 0.09 in. (2.3 mm).

(b) A Welding Procedure Specification (WPS) is prepared describing the capacitor discharge equipment, the combination of materials to be joined, and the technique of application.

(c) Welding operators using low-energy capacitor discharge welding are not required to be qualified.

(d) This Case number shall be shown on the WPS and Manufacturer's Data Report, when applicable.

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Case 2886

Alternate Brazing Requirements for Pressure and Nonpressure Parts

Section IV

Approval Date: August 7, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is brazing of nonpressure parts to pressure parts exempted from the procedure and performance qualification testing in Section IV?

Reply: It is the opinion of the Committee that brazing procedure and performance qualification testing is not required, provided the following requirements are met:

- (a)* The nonpressure parts are not load carrying.
- (b)* This Case number shall be shown on the Manufacturer's Data Report.

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Case 2887-2

Alternate Safety Relief Valve Mounting for Low Mass Watertube Boilers and Water Heaters

Section IV

Approval Date: April 16, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may safety relief valves be mounted below the lowest permissible water level of a low mass water boiler or water heater?

Reply: It is the opinion of the Committee that safety relief valves may be mounted below the lowest permissible water level of a low mass water boiler or water heater, provided the following requirements are met:

(a) Water volume shall be 10 gal (38 L) or less.

(b) A UL-353 or UL-60730-1 and UL-60730-2-15 certified flow sensing device shall be installed to automatically cut off the fuel supply if circulation through the boiler is interrupted.

(c) The safety relief valve inlet piping is connected to the hot water outlet piping.

(d) Safety relief valves shall be installed with their spindles vertical.

(e) The opening or connection between the boiler and any safety relief valve shall have an area at least equal to the nominal inside area of a Schedule 80 pipe (as defined by ASME B36.10) and of the same nominal pipe size as the inlet of the valve.

(f) All other requirements of Section IV shall be met.

(g) This Case number shall be recorded on the Manufacturer's Data Report.

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Case 2888

Use of Silicone Rubber O-Rings for Installing Tubes in Hot Water Heating Boilers and Potable Water Heaters

Section IV

Approval Date: August 24, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may silicone rubber be used as material for O-ring seals under HG-360.3(e) for the construction of hot water heating boilers and potable water heaters?

Reply: It is the opinion of the Committee that silicone rubber may be used as material for O-rings under HG-360.3(e) for the construction of hot water boilers

and potable water heaters, provided the following requirements are met:

(a) The requirements of HG-360.3(e) shall be met except for HG-360.3(e)(4) and HG-360.3(e)(5).

(b) The materials specification shall be ASTM D2000 M3GE 705 .

(c) The O-ring shall be located or shielded from the combustion chamber in such a manner that the temperature of the O-ring will not exceed 450°F (230°C).

(d) This Case number shall be recorded on the Manufacturer's Data Report.

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Case 2889

Alternate NDE Method for Welded Spin Holes

Section VIII, Division 1

Approval Date: July 6, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may alternate nondestructive examination (NDE) methods be used in lieu of the mandatory magnetic particle examination (MT) or liquid penetrant examination (PT) required by UW-34?

Reply: It is the opinion of the Committee that the NDE method of radiographic examination (RT) may be used in lieu of MT or PT required by UW-34, provided that RT shall be performed in accordance with all requirements of Section VIII, Division 1.

This Case number shall be shown on the Manufacturer's Data Report.

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Case 2890-4

Fe-10.5Cr-0.5Mo-V-Nb Material

Section I

Approval Date: May 12, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the following Fe-10.5Cr-0.5Mo-V-Nb, UNS K91060 products be used in Section I construction?

(a) seamless tubes, seamless fittings, and forgings, conforming to the specifications listed in [Table 1](#)

(b) seamless tubes, forged pipe and plate with the chemical analysis shown in [Table 2](#), mechanical properties listed in [Table 3](#), and otherwise conforming to the specifications listed in [Table 4](#)

Reply: It is the opinion of the Committee that the materials listed in the Inquiry may be used in Section I construction, provided the following additional requirements are met:

(a) The material shall be austenitized within the temperature range of 1,920°F to 2,010°F (1050°C to 1100°C) and tempered in the range of 1,380°F to 1,455°F (750°C to 790°C).

(b) The rate of cooling at midthickness from 1,650°F to 900°F (900°C to 480°C) shall be no slower than 9°F/min (5°C/min).

(c) The yield strength and tensile strength values for use in design shall be as shown in [Tables 5](#) and [5M](#).

(d) The minimum hardness shall be 190 HBW or 196 HV.

(e) The maximum allowable stress values for the material shall be those given in [Tables 6](#) and [6M](#).

(f) The maximum use temperature is 1,202°F (650°C).

(g) Physical properties

(1) density: 0.280 lb/in.³ (7750 kg/m³)

(2) linear expansion is expressed in terms of coefficients in [Tables 7](#) and [7M](#)

(3) thermal conductivity and thermal diffusivity: [Tables 8](#) and [8M](#)

(4) Elastic moduli: [Tables 9](#) and [9M](#)

(h) Separate Welding Procedure Qualification in accordance with Section IX shall be required for this material. For purposes of Performance Qualification this material shall be considered P-No. 15F, Group 1. Welding shall be limited to the GTAW, SMAW, and SAW processes. Procedure and performance qualifications qualified under previous versions of this Case do not require requalification.

(i) Postweld heat treatment of this material is mandatory, and the following rules shall apply:

(1) The time requirements shall be those given for P-No. 15E, Group 1 material in [Table PW-39-5](#).

(2) The PWHT temperature range shall be 1,345°F to 1,435°F (730°C to 780°C).

(3) Exemptions to postweld heat treatment for this material shall be in accordance with the rules for P-No. 15E, Group 1 materials in [Table PW-39-5](#).

(j) Cold-forming rules for P91 in [PG-20](#) shall apply, except austenitizing shall be as in (a). Specifically for cold-formed flares, swages, and upsets in tubing or pipe, regardless of the dimension and the amount of cold work, the material shall be reaustenitized and tempered in accordance with (a).

(k) If during the manufacturing any portion of the component is heated to a temperature greater than 1,455°F (790°C), then the component must be reaustenitized and retempered in its entirety in accordance with (a), or that portion of the component heated above 1,455°F (790°C), including the heat-affected zone created by the local heating, must be replaced or must be removed, reaustenitized, and retempered, and then replaced in the component.

(l) Weld strength reduction factors for the CSEF steel group in [Table PG-26](#) shall apply when applicable.

(m) For external pressure design, Section II, Part D, [Figure CS-3](#) shall be used.

(n) This material is a creep strength-enhanced ferritic (CSEF) steel whose creep temperature strength is enhanced by the creation of a precise condition of microstructure, specifically martensite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbonitrides, or other stable and/or metastable phases. Refer to Section I, [PW-10](#) for additional cautionary information.

It has been demonstrated by creep testing that this CSEF steel does not exhibit creep damage intolerant behavior.

(o) This Case number shall be shown in the documentation and marking of the material and on the Manufacturer's Data Report.

Table 1
Specifications and Grades

Product	Specification	Grade
Forgings	SA-182/SA-182M	F115
Seamless fittings	SA-234/SA-234M	WP115
Seamless tube	SA-213/SA-213M	T115

Table 2
Chemical Requirements

Element	Composition Limits, %
Carbon	0.08–0.13
Manganese	0.20–0.50
Phosphorus, max.	0.020
Sulfur, max.	0.005
Silicon	0.15–0.45
Chromium	10.0–11.0
Molybdenum	0.40–0.60
Nickel, max.	0.25
Vanadium	0.18–0.25
Niobium	0.02–0.06
Nitrogen	0.030–0.070
Copper, max.	0.10
Aluminum, max.	0.02
Titanium, max.	0.01
Boron, max.	0.001
Zirconium, max.	0.01
Arsenic, max.	0.010
Tin, max.	0.010
Antimony, max.	0.003
Lead	Report
Tungsten, max.	0.05
N/Al ratio, min.	4.0
CNB, max. [Note (1)]	10.5

NOTE: (1) The Chromium–Nickel balance is defined as

$$CNB = (Cr + 6Si + 4Mo + 1.5W + 11V + 5Cb + 9Ti + 12Al) - (40C + 30N + 4Ni + 2Mn + 1Cu)$$

Table 3
Mechanical Property Requirements

Tensile strength, min., ksi (MPa)	90 (620)
Yield strength, min., ksi (MPa)	65 (450)
Hardness, HBW (HV)	190 to 250 (196 to 265)
Elongation in 2 in. (50.8 mm), min. %	20

[Note (1)]

NOTE: (1) For longitudinal strip tests, a deduction from the basic values of 1.00% for each 0.031 in. (0.8 mm) decrease in wall thickness below 0.312 in. (7.8 mm) shall be made. The following table gives the computed values:

Wall Thickness, in. (mm)	Minimum Elongation in 2 in. (50.8 mm), %
0.312 (7.8)	20.0
0.281 (7.1)	19.0
0.250 (6.4)	18.0
0.219 (5.3)	17.0
0.188 (4.8)	16.0
0.156 (4.0)	15.0
0.125 (3.2)	14.0
0.094 (2.4)	13.0
0.062 (1.5)	12.0
0.035 to 0.062 (0.9 to 1.5), excl.	11.6
0.022 to 0.035 (0.6 to 0.9), excl.	10.9
0.015 to 0.022 (0.4 to 0.6), incl.	10.6

GENERAL NOTE: Where the wall thickness lies between two values shown above, the minimum elongation value shall be determined by the following equation:

(U.S. Customary Units)

$$E = 32t + 10.00$$

(SI Units)

$$E = 1.25t + 10.00$$

where

E = elongation in 2 in. (50.8 mm), %
 t = actual thickness of specimen, in. (mm)

Table 4
Specifications

Product	Specification
Forged pipe	SA-369/SA-369M
Plate	SA-387/SA-387M
Seamless pipe	SA-335/SA-335M

Table 5
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
75	65.3	89.9
100	65.3	89.9
200	59.2	89.9
300	56.8	87.4
400	55.9	85.0
500	55.8	83.5
600	55.6	82.1
650	55.3	81.0
700	54.7	79.5
750	53.7	77.4
800	52.2	74.8
850	50.3	71.4
900	47.8	67.3
950	44.7	62.6
1,000	41.2	57.2
1,050	37.2	51.4
1,100	32.9	45.2
1,150	28.3	39.1
1,200	23.7	33.4
1,250	19.2	28.6

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, General Note (b) applies to these values.
- (2) Section II, Part D, Subpart 1, Table U, General Note (b) applies to these values.

Table 5M
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
21	450	620
40	450	620
65	422	620
100	405	620
125	397	613
150	391	602
175	388	594
200	385	587
225	385	582
250	384	578
275	384	574
300	384	569
325	383	564
350	381	556
375	376	546
400	370	533
425	361	517
450	349	496
475	334	472
500	316	444
525	296	412
550	272	377
575	247	340
600	219	302
625	191	264
650	162	229

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, General Note (b) applies to these values.
- (2) Section II, Part D, Subpart 1, Table U, General Note (b) applies to these values.

Table 6
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi
75	25.7
100	25.7
200	25.7
300	25.0
400	24.3
500	23.9
600	23.4
650	23.1
700	22.7
750	22.1
800	21.4
850	20.4
900	19.2
950	17.9
1,000	16.3
1,050	13.7 [Note (1)]
1,100	10.0 [Note (1)]
1,150	6.9 [Note (1)]
1,200	4.4 [Note (1)]
1,250 [Note (2)]	2.2 [Note (1)]

NOTES:

- (1) These values are obtained from time-dependent properties.
- (2) The value at 1,250°F is for interpolation only; the maximum use temperature is 1,202°F.

Table 6M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa
21	177
40	177
65	177
100	177
125	175
150	172
175	170
200	168
225	166
250	165
275	164
300	163
325	161
350	159
375	156
400	152
425	148
450	142
475	135
500	127
525	118
550	108
575	85.0 [Note (1)]
600	63.3 [Note (1)]
625	45.3 [Note (1)]
650	29.8 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

Table 7
Thermal Expansion

Temperature, °F	Coefficient A, 10^{-6} F^{-1}	Coefficient B, 10^{-6} F^{-1}	Coefficient C, in./100 ft
70	5.8	5.8	0.0
100	5.8	5.8	0.2
200	6.0	5.9	0.9
300	6.3	6.0	1.7
400	6.5	6.1	2.4
500	6.8	6.2	3.2
600	7.0	6.4	4.1
700	7.1	6.5	4.9
800	7.2	6.6	5.8
900	7.3	6.7	6.6
1,000	7.4	6.7	7.5
1,100	7.4	6.8	8.4
1,200	7.3	6.9	9.3
1,300	7.0	6.9	10.2

GENERAL NOTE: Coefficient A is the instantaneous coefficient of thermal expansion $\times 10^{-6}$ (in./in./°F). Coefficient B is the mean coefficient of thermal expansion $\times 10^{-6}$ (in./in./°F) in going from 70°F to indicated temperature. Coefficient C is the linear thermal expansion (in./100 ft) in going from 70°F to indicated temperature.

Table 7M
Thermal Expansion

Temperature, °C	Coefficient A, 10^{-6} K^{-1}	Coefficient B, 10^{-6} K^{-1}	Coefficient C, mm/m
20	10.4	10.4	0.0
50	10.5	10.4	0.3
100	10.9	10.6	0.8
150	11.3	10.8	1.4
200	11.7	11.0	2.0
250	12.2	11.2	2.6
300	12.4	11.4	3.2
350	12.7	11.6	3.8
400	13.0	11.7	4.5
450	13.1	11.9	5.1
500	13.2	12.0	5.8
550	13.4	12.1	6.4
600	13.3	12.3	7.1
650	13.1	12.3	7.8
700	12.7	12.4	8.4

GENERAL NOTE: Coefficient A is the instantaneous coefficient of thermal expansion $\times 10^{-6}$ (mm/mm/°C). Coefficient B is the mean coefficient of thermal expansion $\times 10^{-6}$ (mm/mm/°C) in going from 20°C to indicated temperature. Coefficient C is the linear thermal expansion (mm/m) in going from 20°C to indicated temperature.

Table 8
Thermal Conductivity and Thermal Diffusivity

Temperature, °F	Thermal Conductivity, Btu hr ⁻¹ ft ⁻¹ °F ⁻¹	Thermal Diffusivity, ft ² hr ⁻¹
70	13.4	0.259
100	13.5	0.257
200	13.9	0.257
300	14.2	0.257
400	14.4	0.256
500	14.7	0.254
600	14.8	0.247
700	14.9	0.244
800	15.0	0.234
900	15.0	0.222
1,000	15.0	0.205
1,100	14.9	0.188
1,200	14.8	0.169
1,300	14.7	0.143

Table 8M
Thermal Conductivity and Thermal Diffusivity

Temperature, °C	Thermal Conductivity, $\text{W m}^{-1} \text{ K}^{-1}$	Thermal Diffusivity, $\text{mm}^2 \text{ s}^{-1}$
20	23.1	6.69
50	23.5	6.61
100	24.1	6.64
150	24.5	6.63
200	24.9	6.61
250	25.3	6.59
300	25.5	6.40
350	25.7	6.35
400	25.9	6.18
450	26.0	5.89
500	26.0	5.61
550	25.9	5.18
600	25.8	4.81
650	25.6	4.35
700	25.4	3.74

Table 9
Elastic Moduli

Temperature, °F	Modulus of Elasticity, <i>E</i> , ×10 ⁶ psi	Poisson's Ratio, <i>ν</i>
70	31.4	0.284
100	31.2	0.284
200	30.7	0.288
300	30.2	0.290
400	29.5	0.293
500	28.9	0.296
600	28.2	0.299
700	27.5	0.301
800	26.7	0.304
900	25.7	0.307
1,000	24.6	0.309
1,100	23.5	0.313
1,200	22.1	0.315
1,300	19.4	0.318

Table 9M
Elastic Moduli

Temperature, °C	Modulus of Elasticity, <i>E</i> , GPa	Poisson's Ratio, <i>ν</i>
20	216	0.284
50	214	0.285
100	211	0.288
150	208	0.290
200	204	0.293
250	200	0.295
300	196	0.298
350	191	0.300
400	187	0.303
450	181	0.305
500	175	0.308
550	168	0.310
600	161	0.313
650	152	0.315
700	136	0.318

Case 2892

Use of ASTM A372/A372M-16, Grade N, Classes 100 and 120 and Grade P, Classes 100 and 120

Section VIII, Division 1

Approval Date: October 13, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ASTM A372/A372M-16, Grade N, Classes 100 and 120 and Grade P, Classes 100 and 120 be used for Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that ASTM A372/A372M-16, Grade N, Classes 100 and 120 and Grade P, Classes 100 and 120 may be used for Section VIII, Division 1 construction, provided the following additional requirements are met:

(a) The design temperature shall not exceed 650°F (343°C).

(b) This material shall not be used for welded construction. No welding is permitted on this material.

(c) The steel shall be vacuum degassed before or during the pouring of the ingot or continuous casting as applicable, in order to remove objectionable gases, particularly hydrogen.

(d) The yield strength values, S_y , shall be those shown in Table 1 or Table 1M.

(e) The tensile strength values, S_u , shall be those shown in Table 2 or Table 2M.

(f) Vessels shall be of streamlined design and stress raisers, such as abrupt changes in section, shall be minimized. Openings shall be reinforced in accordance with UG-37; UG-36(c)(3) shall not apply.

(g) This material shall not be used for external pressure applications (e.g., vacuum service) or where other loads resulting in compressive stresses are applied.

(h) The requirements of UF-55 for ultrasonic examination of SA-372/SA-372M, Grade J, Class 110 material shall be applied to ASTM A372/A372M, Grades N and P, Classes 100 and 120 that are the subject of this Case.

(i) The allowable stress values shall be those shown in Table 3 or Table 3M.

(j) The rules of Section VIII, Division 1, Subsection C, Part UCS shall apply.

(k) Vessels may be constructed in accordance with the requirements of Mandatory Appendix 22. If that is done, the provisions of 22-3(a) shall apply, using the tensile strength values in Table 2 or 2M. All other requirements of Mandatory Appendix 22 shall apply.

(l) This Case number shall be shown on the material marking and documentation, and the Manufacturer's Data Report.

Table 1
Yield Strength Values

Specification No., Grade, Class	Yield Strength, S_y , ksi, for Metal Temperature Not Exceeding, °F								
	100	150	200	250	300	400	500	600	650
ASTM A372/A372M, Grade N, Class 100	100.0	97.5	96.0	94.6	93.5	91.9	90.6	88.9	87.6
ASTM A372/A372M, Grade P, Class 100	100.0	97.5	96.0	94.6	93.5	91.9	90.6	88.9	87.6
ASTM A372/A372M, Grade N, Class 120	120.0	117.0	115.2	113.6	112.2	110.3	108.8	106.7	105.2
ASTM A372/A372M, Grade P, Class 120	120.0	117.0	115.2	113.6	112.2	110.3	108.8	106.7	105.2

Table 1M
Yield Strength Values

Specification No., Grade, Class	Yield Strength, S_y , MPa, for Metal Temperature Not Exceeding, °C												
	40	65	100	125	150	175	200	225	250	275	300	325	350 [Note (1)]
ASTM A372/A372M, Grade N, Class 100	689	673	660	651	644	639	634	630	626	622	617	610	601
ASTM A372/A372M, Grade P, Class 100	689	673	660	651	644	639	634	630	626	622	617	610	601
ASTM A372/A372M, Grade N, Class 120	827	807	792	782	773	767	761	757	752	747	740	733	722
ASTM A372/A372M, Grade P, Class 120	827	807	792	782	773	767	761	757	752	747	740	733	722

NOTE: (1) The maximum design temperature for these materials is 343°C. Values above 343°C are provided only for the purpose of interpolation.

Table 2
Tensile Strength Values

Specification No., Grade, Class	Tensile Strength, S_u , ksi, for Metal Temperature Not Exceeding, °F						
	100	200	300	400	500	600	650
ASTM A372/A372M, Grade N, Class 100	115.0	115.0	115.0	115.0	115.0	115.0	113.2
ASTM A372/A372M, Grade P, Class 100	115.0	115.0	115.0	115.0	115.0	115.0	113.2
ASTM A372/A372M, Grade N, Class 120	135.0	135.0	135.0	135.0	135.0	135.0	132.9
ASTM A372/A372M, Grade P, Class 120	135.0	135.0	135.0	135.0	135.0	135.0	132.9

Table 2M
Tensile Strength Values

Specification No., Grade, Class	Tensile Strength, S_u , MPa, for Metal Temperature Not Exceeding, °C							
	40	100	150	200	250	300	325	350 [Note (1)]
ASTM A372/A372M, Grade N, Class 100	793	793	793	793	793	793	790	776
ASTM A372/A372M, Grade P, Class 100	793	793	793	793	793	793	790	776
ASTM A372/A372M, Grade N, Class 120	931	931	931	931	931	931	928	911
ASTM A372/A372M, Grade P, Class 120	931	931	931	931	931	931	928	911

NOTE: (1) The maximum design temperature for these materials is 343°C. Values above 343°C are provided only for the purpose of interpolation.

Table 3
Allowable Stress Values

Specification No., Grade, Class	Allowable Stress, ksi, for Metal Temperature Not Exceeding, °F							
	100	200	300	400	300	500	650	
ASTM A372/A372M, Grade N, Class 100	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.4
ASTM A372/A372M, Grade P, Class 100	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.4
ASTM A372/A372M, Grade N, Class 120	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.0
ASTM A372/A372M, Grade P, Class 120	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.0

Table 3M
Allowable Stress Values

Specification No., Grade, Class	Allowable Stress, MPa, for Metal Temperature Not Exceeding, °C									
	40	65	100	125	150	200	250	300	325	350 [Note (1)]
ASTM A372/A372M, Grade N, Class 100	227	227	227	227	227	227	227	227	226	222
ASTM A372/A372M, Grade P, Class 100	227	227	227	227	227	227	227	227	226	222
ASTM A372/A372M, Grade N, Class 120	266	266	266	266	266	266	266	266	265	261
ASTM A372/A372M, Grade P, Class 120	266	266	266	266	266	266	266	266	265	261

NOTE: (1) The maximum design temperature for these materials is 343°C. Values above 343°C are provided only for the purpose of interpolation.

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Case 2893

Modular Hot Water Supply Boilers

Section IV

Approval Date: October 16, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may modular hot water supply boilers be certified as a single boiler?

Reply: It is the opinion of the Committee that modular hot water supply boilers may be certified as a single boiler, provided the following requirements are met:

(a) A complete modular hot water supply boiler shall be documented on a single Manufacturer's Data Report by documenting "Master Data Report" in the Remarks section of the data report.

(b) When individual modules are certified on a single data report, the serial number of each individual module shall be listed in the Remarks section of the master data report, either Form H-2 or H-3, as applicable, with the single data reports attached.

(c) The assembled modules shall be provided with a single nameplate stamping for the modular hot water supply boiler with the aggregate input Btu/hr (kW) noted on the nameplate stamping.

(d) Individual modules shall be marked in a manner traceable to the assembled modular boiler nameplate and data report.

(e) Supply (distribution) and cold water return headers shall be constructed in accordance with Section IV and recorded on the Master Data Report.

(f) The pressure or altitude gage required on each module per HG-611 may be replaced by a single pressure or altitude gage located on the supply (distribution) header.

(g) The thermometer required on each module per HG-612 may be replaced by a single thermometer located on the supply (distribution) header.

(h) The assembled modular hot water supply boiler shall be installed without stop valves between modules and should be provided with a single set of stop valves on the common supply (distribution or discharge) and return headers. Flow control valves and circulating pumps may be located in the inlet lines of the individual modules.

(i) The safety valve(s) required on each module by HG-400.2 may be replaced by one or more safety valves located on the supply (distribution) header.

(j) No valve of any kind shall be installed between any module heat exchanger and the safety valve.

(k) The bottom drain valve(s) required on each module by HG-715(c) may be replaced by one or more bottom drain valve(s) located at the lowest practicable point on the hot water supply boiler, or the lowest point on piping connected to the boiler.

(l) All other requirements of Section IV shall apply.

(m) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2894

Use of UNS S31254 Austenitic Stainless Steel Plate, Sheet, Strip, and Tube in the Welded Construction of Hot Water Heating Boilers

Section IV

Approval Date: October 16, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S31254 austenitic stainless steel in SA-240/SA-240M plate, sheet, strip and SA-249/SA-249M welded tube be used in the welded construction of Section IV hot water heating boilers?

Reply: It is the opinion of the Committee that UNS S31254 in SA-240/SA-240M plate, sheet, strip and SA-249/SA-249M welded tube may be used in the welded construction of Section IV hot water heating boilers, provided the following requirements are met:

(a) The allowable stress shall be as listed in [Tables 1, 1M, 2, and 2M](#).

(b) Welding procedure and performance qualification shall be conducted in accordance with Section IX. These materials shall be considered P-No. 8, Group No. 4.

(c) For external pressure Section II, Part D, Figure HA-2 shall be used.

(d) SA-240/SA-240M plate, sheet, and strip may utilize the minimum thickness exceptions of HF-301.1(c) up to 160 psi (1 100 kPa).

(e) SA-249/SA-249M welded tube may utilize the thickness requirements of HF-204.3.

(f) All other requirements of Section IV shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for SA-240/SA-240M
Plate, Sheet, Strip

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Sheet and Strip	Plate
100	20.0	19.0
200	20.0	19.0
300	19.0	18.1
400	18.1	17.2
500	17.5	16.6

Table 1M
Maximum Allowable Stress Values for SA-240/SA-240M
Plate, Sheet, Strip

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Sheet and Strip	Plate
40	138	131
100	138	131
150	131	125
200	125	119
250	121	115
275 [Note (1)]	120	114

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

Table 2
Maximum Allowable Stress Values for SA-249/SA-249M
Welded Tube

For Metal Temperatures Not Exceeding, °F	For $t \leq 0.187$ in., Maximum Allowable Stress Values, ksi
100	16.7
200	16.7
300	15.8
400	15.1
500	14.6

GENERAL NOTE: For welded tube the allowable stress values have been multiplied by a factor of 0.85.

Table 2M
Maximum Allowable Stress Values for SA-249/SA-249M
Welded Tube

For Metal Temperatures Not Exceeding, °C	For $t \leq 5$ mm, Maximum Allowable Stress Values, MPa
40	115
100	114
150	109
200	104
250	101
275 [Note (1)]	100

GENERAL NOTE: For welded tube the allowable stress values have been multiplied by a factor of 0.85.

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

Case 2895

Use of UNS S31254 Austenitic Stainless Steel Plate, Sheet, Strip, and Tube in the Manufacture of Part HLW Water Heaters and Storage Tanks

Section IV

Approval Date: October 16, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S31254 austenitic stainless steel in SA-240/SA-240M plate, sheet, strip and SA-249/SA-249M welded tube be used in the welded construction of unlined Section IV, Part HLW water heaters and storage tanks?

Reply: It is the opinion of the Committee that UNS S31254 in SA-240/SA-240M plate, sheet, strip and SA-249/SA-249M welded tube may be used in the welded construction of Section IV unlined water

heaters and storage tanks, provided the following requirements are met:

(a) The allowable stress shall be as listed in [Tables 1, 1M, 2, and 2M](#).

(b) Welding procedure and performance qualification shall be conducted in accordance with Section IX. These materials shall be considered P-No. 8, Group No. 4.

(c) For external pressure Section II, Part D, Figure HA-2 shall be used.

(d) The maximum design temperature shall be 500°F (260°C).

(e) All other requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values for SA-240/SA-240M
Plate, Sheet, Strip

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Sheet and Strip	Plate
100	25.0	23.8
200	24.5	23.8
300	21.9	21.9
400	20.3	20.3
500	19.1	19.1

Table 1M
Maximum Allowable Stress Values for SA-240/SA-240M
Plate, Sheet, Strip

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Sheet and Strip	Plate
40	172	164
100	167	163
150	151	151
200	141	141
250	133	133
275 [Note (1)]	130	129

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

Table 2
Maximum Allowable Stress Values for SA-249/SA-249M
Welded Tube

For Metal Temperatures Not Exceeding, °F	For $t \leq 0.187$ in., Maximum Allowable Stress Values, ksi
100	20.8
200	20.8
300	18.6
400	17.2
500	16.2

GENERAL NOTE: For welded tube the allowable stress values have been multiplied by a factor of 0.85.

Table 2M
Maximum Allowable Stress Values for SA-249/SA-249M
Welded Tube

For Metal Temperatures Not Exceeding, °C	For $t \leq 5$ mm, Maximum Allowable Stress Values, MPa
40	143
100	141
150	128
200	120
250	113
275 [Note (1)]	110

GENERAL NOTE: For welded tube the allowable stress values have been multiplied by a factor of 0.85.

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

Case 2896

Alternative Methods for Stamping

Section I

Approval Date: August 9, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternative methods may be used to stamp the ASME Certification Mark, Designator, and other data required by PG-106.1 and PG-106.4?

Reply: It is the opinion of the Committee that alternative methods may be used, provided the following requirements are met:

(a) Acceptable alternative methods include etching (laser, plasma, or chemical), dot peening, and engraving.

(b) The applied ASME Certification Mark shall be permanent, clearly legible, and identical in size and configuration to the ASME-issued stamp.

(c) The process controls for the method of marking shall be described in the Quality Control System and shall be acceptable to the Authorized Inspector.

(d) The external surface condition where the marking is to be applied shall be clean, uncoated, and unpainted.

(e) This Case number shall be recorded on the Manufacturer's Data Report.

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Case 2897-1

Substitution of Base Metals for Weld Metal Overlay

Section I; Section IX

Approval Date: December 18, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the base metal P-Number in a welding procedure specification (WPS) qualified for depositing weld metal overlay be changed to a lower base metal P-Number without requalification of the WPS in lieu of the rules of QW-403.20?

Reply: It is the opinion of the Committee that the base metal P-Number in a WPS qualified for depositing weld metal overlay may be changed to a lower base metal

P-Number without requalification of the WPS in lieu of the rules of QW-403.20, provided the following requirements are met:

(a) The chemical composition of the weld metal overlay is not specified in the WPS.

(b) The WPS is qualified for weld metal overlay on a P-No. 5A or any lower P-Number base metal.

(c) The substituted base metal is assigned a lower P-Number than the originally qualified base metal.

(d) This Case number shall be listed on the WPS and the Manufacturer's Data Report.

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Case 2898-1

Use of JIS G 4305:2012 Alloy SUS444 in the Construction of Heating Boilers Under Part HF

Section IV

Approval Date: June 19, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may alloy SUS444 ferritic stainless steel plate, sheet, and strip meeting the material requirements of JIS G 4305:2012 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that alloy SUS444 ferritic stainless steel plate, sheet, and strip meeting the material requirements of JIS G 4305:2012 may be used in the construction of heating boilers under Section IV, Part HF, provided the following requirements are met:

(a) The allowable stress values for plate, sheet, and strip in accordance with alloy SUS444 shall be as listed in [Tables 1](#) and [1M](#).

(b) The minimum tensile strength shall be 59.5 ksi (410 MPa).

(c) The minimum yield strength shall be 35.5 ksi (245 MPa).

(d) For the purpose of welding and brazing procedures and performance qualifications, this material shall be considered P-No. 7, Group 2.

(e) For external pressure, Figure CS-2 of Section II, Part D shall be used.

(f) The maximum design temperature shall be 500°F (260°C).

(g) The water temperature shall not exceed 250°F (125°C).

(h) This material with a minimum thickness of 0.0157 in. (0.4 mm) may be used for the construction of Section IV heating boilers, provided the stainless steel plate is not exposed to primary furnace gases.

(i) This material may utilize the minimum thickness exceptions of HF-301.1(c).

(j) A material test report including tensile and yield strength (proof stress) values shall be provided for all pressure-retaining plate materials to verify that the mechanical properties listed in [Table 2](#) are met.

(k) All other requirements of Section IV shall be met.

(l) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	11.9
150	11.9
200	11.9
250	11.7
300	11.5
350	11.4
400	11.3
450	11.1
500	11.0

GENERAL NOTE: The maximum thickness of the material covered by this Table is $\frac{3}{8}$ in.

Table 1M
Maximum Allowable Stress Values

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	81.8
65	81.7
100	81.6
125	80.4
150	78.4
175	74.8
200	71.9
225	69.5
250	67.7
275 [Note (1)]	65.9

GENERAL NOTE: The maximum thickness of the material covered by this Table is 10.0 mm.

NOTE: (1) The maximum use temperature shall be 260°C. The value for 275°C temperature is provided for interpolation only.

Table 2
**JIS G 4305, Alloy SUS444 Chemical Composition for
Plate, Sheet, and Strip**

Element	Composition
C	0.025 max.
Mn	1.00 max.
P	0.040 max.
S	0.030 max.
Si	1.00 max.
Cr	17.00–20.00
Ni	[Note (1)]
Mo	1.75–2.50
N	0.025 max.
Other elements [Ti+Cb (Nb)]	Ti, Nb, Zr, or combination thereof: 8 × (C% + N%) to 0.80

NOTE: (1) Ni shall not be added exceeding 0.60%.

Case 2899-1

Use of JIS G 4305:2012 Alloy SUS315J1 in the Construction of Heating Boilers Under Part HF

Section IV

Approval Date: June 19, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may solution annealed alloy SUS315J1 austenitic stainless steel plate, sheet, and strip meeting the material requirements of JIS G 4305:2012 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that solution annealed alloy SUS315J1 austenitic stainless steel plate, sheet, and strip meeting the material requirements of JIS G 4305:2012 may be used in the construction of heating boilers under Section IV, Part HF, provided the following requirements are met:

(a) The allowable stress values for stainless steel plate, sheet, and strip in accordance with alloy SUS315J1 shall be as listed in [Tables 1](#) and [1M](#).

(b) The minimum tensile strength shall be 75.5 ksi (520 MPa).

(c) The minimum yield strength shall be 30 ksi (205 MPa).

(d) Separate welding procedure qualifications, conducted in accordance with Section IX shall be required for this material. For the purpose of welding and brazing

procedures and performance qualifications, this material shall be considered P-No. 8, Group 1.

(e) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of JIS G 4305:2012, Annex JA shall apply.

(f) For external pressure, Figure HA-1 of Section II, Part D shall be used.

(g) The maximum design temperature shall be 500°F (260°C).

(h) The water temperature shall not exceed 210°F (99°C).

(i) This material may utilize the minimum thickness exceptions of HF-301.1(c).

(j) This material with a minimum thickness of 0.0157 in. (0.4 mm) may be used for the construction of Section IV heating boilers, provided the stainless steel plate is not exposed to primary furnace gases.

(k) A material test report including tensile and yield strength (proof stress) values shall be provided for all pressure-retaining plate materials to verify that the mechanical properties listed in [Table 2](#) are met.

(l) All other requirements of Section IV shall be met.

(m) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature, °F	Maximum Allowable Stress Values, ksi
Up to 100	15.0
150	15.0
200	15.0
250	14.8
300	14.6
350	14.5
400	14.3
450	13.8
500	13.3

Table 2
JIS G 4305, Alloy SUS315J1 Chemical Composition for Plate, Sheet, and Strip

Element	Composition
C	0.08 max.
Mn	2.00 max.
P	0.045 max.
S	0.030 max.
Si	0.50-2.50
Cr	17.0-20.5
Ni	8.5-11.5
Mo	0.50-1.50
Cu	0.50-3.50
N	...

Table 1M
Maximum Allowable Stress Values

For Metal Temperature, °C	Maximum Allowable Stress Values, MPa
Up to 40	103.4
65	103.3
100	103.2
125	101.8
150	100.4
175	99.8
200	98.7
225	96.0
250	92.7
275 [Note (1)]	90.7

NOTE: (1) The maximum allowable use temperature is 260°C. The value for 275°C is provided for interpolation only.

Case 2900-1

Use of JIS G 4305:2012 Alloy SUS304L in the Construction of Heating Boilers Under Part HF

Section IV

Approval Date: June 19, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may alloy SUS304L plate, sheet, and strip meeting the material requirements of JIS G 4305:2012 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that alloy SUS304L plate, sheet, and strip meeting the material requirements of JIS G 4305:2012 may be used in the construction of heating boilers under Section IV, Part HF, provided the following requirements are met:

(a) The allowable stress values for plate, sheet and strip in accordance with alloy SUS304L shall be as listed in [Tables 1](#) and [1M](#).

(b) The minimum tensile strength shall be 69.5 ksi (480 MPa).

(c) The minimum yield strength shall be 25.5 ksi (175 MPa).

(d) For the purpose of welding and brazing procedures and performance qualifications, this material shall be considered P-No. 8, Group 1.

(e) For external pressure, Figure HA-3 of Section II, Part D shall be used.

(f) The maximum design temperature shall be 500°F (260°C).

(g) The water temperature shall not exceed 210°F (99°C).

(h) This material with a minimum thickness of 0.0157 in. (0.4 mm) may be used for the construction of Section IV heating boilers, provided the stainless steel plate is not exposed to primary furnace gases.

(i) This material may utilize the minimum thickness exceptions of HF-301.1(c).

(j) A material test report including tensile and yield strength (proof stress) values shall be provided for all pressure-retaining plate materials to verify that the mechanical properties listed in [Table 2](#) are met.

(k) All other requirements of Section IV shall be met.

(l) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Value, ksi
100	14.0
150	13.9
200	13.2
250	12.7
300	12.2
350	12.0
400	11.7
450	11.3
500	10.9

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	96.6
65	93.5
100	90.4
125	87.3
150	84.2
175	82.7
200	81.7
225	78.0
250	76.0
275 [Note (1)]	74.0

NOTE: (1) The maximum allowable use temperature is 260°C. The value for 275°C is provided for interpolation only.

Table 2
JIS G 4305, Alloy SUS304L Chemical Composition for Plate, Sheet, and Strip

Element	Composition
C	0.030 max.
Mn	2.00 max.
P	0.045 max.
S	0.030 max.
Si	1.00 max.
Cr	18.00–20.00
Ni	9.00–13.00
N	...
Grade	18Cr-8Ni
Tensile strength	69.5 ksi
Yield strength	25.5 ksi

Case 2901-1

Evaluation of External Loads on Welding Neck Flanges Covered by Section VIII, Division 1, UG-44(a)(2), (a)(9), and (a)(10); or Section VIII, Division 2, 4.1.11.1(a) and (g), and 4.1.11.3

Section VIII, Division 1; Section VIII, Division 2

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May additional rules for evaluating external loads (forces and moments) on flanged joints with weld neck flanges be used to satisfy the rules of Section VIII, Division 1 or Section VIII, Division 2?

Reply: It is the opinion of the Committee that external loads (forces and bending moments) may be evaluated for welding neck flanges chosen in accordance with Section VIII, Division 1, UG-44(a)(2), (a)(9), and (a)(10); or Section VIII, Division 2, 4.1.11.1 (a) and (g), and 4.1.11.3, provided the following requirements are met:

(a) The actual assembly bolt load (see Section VIII, Division 1, Nonmandatory Appendix S and Section VIII, Division 2, 4.16.11) shall comply with ASME PCC-1, Appendix O.

(b) The bolt material is SA-193, B8, Class 2 or has a higher allowable stress at the specified bolt size.

(c) The combination of vessel design pressure (corrected for static pressure acting on the flange) with external moment and external axial tensile force

shall satisfy the following equation, and the units of the variables shall be consistent with the pressure rating.

$$P_D + \frac{16M_E + 4F_E G}{\pi G^3} \leq (1 + F_M)P_R$$

(d) This Case number shall be recorded on the Manufacturer's Data Report (Section VIII, Division 1, UG-120) or Manufacturer's Design Report (Section VIII, Division 2, 2.3.3).

(e) Nomenclature

F_E = external tensile axial force

F_M = moment factor in accordance with [Table 1](#)

G = gasket reaction diameter (see Section VIII, Division 1, Mandatory Appendix 2, 2-3 and Section VIII, Division 2, 4.16.12)

M_E = external moment

P_D = vessel design pressure (corrected for static pressure acting on the flange) at the design temperature

P_R = flange pressure rating at design temperature

Table 1
Moment Factor, F_M

Size, NPS (DN)	Flange Standard and Pressure Class					
	B16.5, Cl. 150	B16.5, Cl. 300	B16.5, Cl. 600	B16.5, Cl. 900	B16.5, Cl. 1500	B16.5, Cl. 2500
½ (15)	23.0	11.5	5.7	7.1	4.2	2.5
¼ (20)	15.3	19.1	4.4	4.3	2.5	1.5
1 (25)	13.9	7.8	3.7	3.9	2.3	1.4
1½ (40)	5.5	5.1	2.4	2.7	1.5	1.0
2 (50)	5.6	4.3	2.1	2.7	1.6	1.0
2½ (65)	4.0	3.8	1.8	2.4	0.73	0.98
3 (80)	2.5	3.0	1.4	1.4	1.0	0.75
4 (100)	3.3	1.8	1.3	1.3	0.84	0.66
5 (125)	3.4	1.1	1.1	1.1	0.75	0.64
6 (150)	2.3	1.2	1.2	1.0	0.66	0.59
8 (175)	1.2	0.94	0.85	0.8	0.54	0.57
10 (250)	1.9	1.2	1.0	0.59	0.47	0.64
12 (300)	1.2	1.1	0.84	0.61	0.53	0.5
14 (350)	1.4	1.2	0.9	0.54	0.6	...
16 (400)	1.4	1.1	0.79	0.41	0.52	...
18 (450)	1.4	0.98	0.66	0.46	0.44	...
20 (500)	1.5	0.72	0.65	0.32	0.42	...
24 (600)	1.3	0.78	0.51	0.37	0.38	...

Size, NPS (DN)	Flange Standard and Pressure Class					
	B16.47A, Cl. 150	B16.47A, Cl. 300	B16.47A, Cl. 600	B16.47A, Cl. 900	B16.47A, Cl. 1500	B16.47A, Cl. 2500
26 (650)	0.90	0.50	0.33	0.34	...	...
28 (700)	0.85	0.42	0.28	0.38	...	...
30 (750)	0.74	0.43	0.22	0.26	...	...
32 (800)	1.1	0.44	0.21	0.29	...	...
34 (850)	1.1	0.49	0.25	0.32	...	...
36 (900)	0.90	0.50	0.22	0.23	...	...
38 (950)	0.76	0.25	0.20	0.21	...	...
40 (1000)	0.79	0.29	0.22	0.16	...	...
42 (1050)	0.72	0.22	0.20	0.20	...	...
44 (1100)	0.66	0.24	0.23	0.13	...	...
46 (1150)	0.62	0.21	0.17	0.15	...	...
48 (1200)	0.64	0.23	0.15	0.10	...	...
50 (1250)	0.92	0.25	0.14	...	...	...
52 (1300)	0.82	0.20	0.18	...	...	...
54 (1350)	0.72	0.22	0.13	...	...	...
56 (1400)	0.75	0.17	0.20	...	...	...
58 (1450)	0.66	0.18	0.14	...	...	...
60 (1500)	0.68	0.16	0.11	...	...	...

Size, NPS (DN)	Flange Standard and Pressure Class					
	B16.47B, Cl. 150	B16.47B, Cl. 300	B16.47B, Cl. 600	B16.47B, Cl. 900	B16.47B, Cl. 1500	B16.47B, Cl. 2500
26 (650)	0.47	0.55	0.16	0.14	...	...
28 (700)	0.44	0.53	0.20	0.18	...	...
30 (750)	0.35	0.57	0.15	0.22	...	...
32 (800)	0.37	0.55	0.16	0.13	...	...
34 (850)	0.36	0.46	0.14	0.16	...	...
36 (900)	0.36	0.43	0.18	0.15	...	...
38 (950)	0.42	0.29	...	...	...	...
40 (1000)	0.41	0.25	...	...	...	...
42 (1050)	0.41	0.22	...	...	...	...
44 (1100)	0.39	0.20	...	...	...	...

Table 1
Moment Factor, F_M (Cont'd)

Size, NPS (DN)	Flange Standard and Pressure Class (Cont'd)					
	B16.47B, Cl. 150	B16.47B, Cl. 300	B16.47B, Cl. 600	B16.47B, Cl. 900	B16.47B, Cl. 1500	B16.47B, Cl. 2500
46 (1150)	0.29	0.16	...	...	...	...
48 (1200)	0.30	0.27	...	...	...	...
50 (1250)	0.30	0.11	...	...	...	...
52 (1300)	0.28	0.11	...	...	...	...
54 (1350)	0.21	0.25	...	...	...	...
56 (1400)	0.23	0.12	...	...	...	...
58 (1450)	0.12	0.09	...	...	...	...
60 (1500)	0.13	0.03	...	...	...	...

GENERAL NOTES:

- (a) The combinations of size ranges and flange pressure classes for which this table gives no moment factor value are outside the scope of this Case.
- (b) The designer should consider reducing the allowable factor if the loading is primarily sustained in nature, and the bolted flange joint operates at a temperature where gasket creep/relaxation will be significant [typically above 450°F (232°C) metal temperature].

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Case 2902

Marking by Laser Annealing of Part HLW Water Heaters and Storage Heaters

Section IV

Approval Date: December 12, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may laser annealing be used in marking of Part HLW water heaters and storage tanks with the information including Certification Mark in accordance with HLW-602?

Reply: It is the opinion of the Committee that laser annealing may be used in marking of Part HLW water heaters and storage tanks with the information including Certification Mark in accordance with HLW-602, provided the following requirements are met:

- (a) The required marking shall be performed by the Manufacturer of the certified vessel only.
- (b) The required marking shall be applied directly to the water heater vessel or on the nameplate permanently fastened to the water heater vessel.
- (c) The material subjected to marking shall be limited to stainless steels.

(d) The arrangement and scope of marked data shall be in accordance with HLW-602.1.

(e) The data shall be in characters not smaller than $\frac{5}{16}$ in. (8 mm) and shall be readable. The graphic image of the Certification Mark shall conform to the proportions of the official Certification Mark.

(f) When there is insufficient space for the marking required in (e), smaller letter dimensions may be used but shall be no smaller than $\frac{5}{32}$ in. (4 mm).

(g) The marking process shall leave a permanent and legible mark.

(h) The required marking shall not be covered by insulation or other material, unless the requirements of HLW-602.3 are met.

(i) The process controls for marking by laser annealing shall be described in the Quality Control System and be acceptable to the Authorized Inspector.

(j) All other requirements of Section IV, Part HLW shall apply.

(k) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2903-1

20Cr-8.5Ni-0.7Mo-0.2N, UNS S31655 Austenitic Steel, Alloy Plate, Sheet, and Strip, Welded Tubing, Seamless and Welded Pipe

Section VIII, Division 1

Approval Date: December 7, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S31655 austenitic stainless steel, plate, sheet, and strip, welded tubing, seamless and welded pipe in accordance with ASTM A240/A240M-17, ASTM A249/A249M-16a, ASTM A312/A312M-18, and ASTM A358/A358M-19 be used in Section VIII, Division 1 welded and nonwelded construction?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section VIII, Division 1 welded and nonwelded construction, provided the following requirements are met:

(a) The physical properties for UNS S31655 are as follows:

(1) mean linear thermal expansion coefficients, as given in [Tables 1](#) and [1M](#)

(2) thermal conductivity at 68°F (20°C): 8.00 Btu/hr-ft-°F (13.8 W/m °C)

(3) density: 0.283 lb/in.³ (7870 kg/m³)

(4) modulus of elasticity at 68°F (20°C): 29.7 × 10⁶ psi (205 × 10³ MPa)

(5) Poisson's ratio: 0.3

(b) The yield strength and tensile strength values for use in design shall be as shown in [Tables 2](#) and [2M](#).

(c) The maximum allowable stress values for the material shall be those given in [Tables 3](#) and [3M](#). The maximum design temperature shall be 850°F (454°C).

(d) This material shall be considered P-No. 8 Group 3.

(e) For ASTM A358/A358M, Supplementary Requirement S8 is mandatory.

(f) Heat treatment after welding is neither required nor prohibited, but if it is performed it shall be an annealing heat treatment as required by the material specifications.

(g) For external pressure design, Section II, Part D, Figure HA-2 shall be used.

(h) The rules for austenitic stainless steels in Section VIII, Division 1 Subsection C, Part UHA shall apply.

(i) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Mean Linear Thermal Expansion Coefficients

Temperature Range, °F	Mean Linear Thermal Expansion Coefficient
68–212	8.2×10^{-6}
68–392	9.2×10^{-6}
68–572	9.9×10^{-6}
68–752	10.2×10^{-6}
68–932	10.3×10^{-6}

Table 1M
Mean Linear Thermal Expansion Coefficients

Temperature Range, °C	Mean Linear Thermal Expansion Coefficient
20–100	14.8×10^{-6}
20–200	16.5×10^{-6}
20–300	17.8×10^{-6}
20–400	18.3×10^{-6}
20–500	18.6×10^{-6}

**Table 2
Yield and Tensile Strength Values**

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
75	45.0	92.1
100	45.0	92.1
200	35.9	90.8
300	31.7	85.1
400	29.0	81.3
500	27.3	78.8
600	26.1	77.3
650	25.6	76.6
700	25.1	76.1
750	24.6	75.4
800	24.1	74.6
850	23.6	73.6

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, Note (b) applies to these values.
- (2) Section II, Part D, Subpart 1, Table U, Note (b) applies to these values.

**Table 2M
Yield and Tensile Strength Values**

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
21	310	635
40	310	635
65	268	635
100	243	620
125	229	602
150	218	586
175	209	573
200	201	562
225	195	553
250	190	546
275	186	540
300	182	535
325	179	531
350	176	528
375	173	524
400	170	520
425	167	515
450	163	509
475	160	501

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, Note (b) applies to these values.
- (2) Section II, Part D, Subpart 1, Table U, Note (b) applies to these values.

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
75	26.3
100	26.3
200	23.9, 25.9 [Note (2)]
300	21.1, 24.3 [Note (2)]
400	19.3, 23.2 [Note (2)]
500	18.2, 22.5 [Note (2)]
600	17.4, 22.1 [Note (2)]
650	17.1, 21.9 [Note (2)]
700	16.8, 21.7 [Note (2)]
750	16.4, 21.5 [Note (2)]
800	16.1, 21.3 [Note (2)]
850	15.7, 21.0 [Note (2)]

PRECAUTION: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

NOTES:

- (1) A weld efficiency factor of 0.85 shall be applied to welded pipe and welded tubing.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
21	181
40	181
65	179, 181 [Note (2)]
100	162, 177 [Note (2)]
125	153, 172 [Note (2)]
150	145, 168 [Note (2)]
175	139, 164 [Note (2)]
200	134, 161 [Note (2)]
225	130, 158 [Note (2)]
250	127, 156 [Note (2)]
275	124, 154 [Note (2)]
300	121, 153 [Note (2)]
325	119, 152 [Note (2)]
350	117, 151 [Note (2)]
375	115, 150 [Note (2)]
400	113, 148 [Note (2)]
425	111, 147 [Note (2)]
450	109, 145 [Note (2)]
475 [Note (3)]	107, 143 [Note (2)]

PRECAUTION: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

NOTES:

- (1) A weld efficiency factor of 0.85 shall be applied to welded pipe and welded tubing.
- (2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (3) The value at 475°C is for interpolation only. The maximum use temperature is 454°C.

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Case 2904

HLW-401.4(a), Distortion in Lined Vessels

(25)

Section IV

Approval Date: December 18, 2017

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the distortion limit in HLW-401.4(a) be exceeded?

Reply: It is the opinion of the Committee that compliance with HLW-401.4(a) is not required, provided the following requirements are met:

(a) The pressure vessel employs a lining that requires baking the vessel at temperatures in excess of 1,000°F (538°C).

(b) The maximum allowable distortion is as required in HLW-401.4 with the following modifications:

(1) The diameter measurements shall be made after baking the lining.

(2) The difference between the maximum and minimum mean diameters shall not exceed 3%.

(c) All other requirements of Section IV shall be met.

(d) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2905

Use of ASME B31.3, Appendix L Aluminum Pipe Flanges

Section VIII, Division 1

Approval Date: December 11, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may aluminum pipe flanges conforming to ASME B31.3-2016, Appendix L be used as a standard pressure part that complies with an ASME product standard in accordance with UG-11(c) for Section VIII, Division 1 application?

Reply: It is the opinion of the Committee that aluminum pipe flanges conforming to ASME B31.3-2016, Appendix L may be used as a standard pressure part that complies with an ASME product standard in accordance with UG-11(c) for Section VIII, Division 1 application, provided the following requirements are met:

(a) The pressure-temperature ratings shall be in accordance with ASME B31.3, Appendix L.

(b) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2906

Table PW-39-1, Exemptions From Postweld Heat Treatment for P-No. 1 Group 1 Materials With CE Greater Than 0.45

Section I

Approval Date: December 21, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may P-No. 1 Group 1 materials with CE greater than 0.45 used in Section I construction be exempt from postweld heat treatment?

Reply: It is the opinion of the Committee that P-No. 1 Group 1 materials with CE greater than 0.45 used in Section I construction are exempt from postweld heat treatment, provided the following requirements are met:

(a) When the nominal thickness of a weld as defined in PW-39.3 does not exceed $\frac{3}{4}$ in. (19 mm), and a minimum preheat of 200°F (95°C) is applied when the nominal thickness of any of the base metals in the weld joint exceeds 1 in. (25 mm). For stays welded in accordance with PW-19, the diameter of the stay is not used to determine preheat requirements.

(b) All other requirements of Section I shall be met.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2907

Use of ASTM A372/A372M-16, Grade N, Classes 100 and 120 and Grade P, Classes 100 and 120

Section VIII, Division 3

Approval Date: December 11, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ASTM A372/A372M-16, Grade N, Classes 100 and 120 and Grade P, Classes 100 and 120 be used for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that ASTM A372/A372M-16, Grade N, Classes 100 and 120 and Grade P, Classes 100 and 120 may be used for Section VIII, Division 3 construction, provided the following additional requirements are met:

(a) The design temperature shall not exceed 650°F (343°C).

(b) This material shall not be used for welded construction. No welding is permitted on this material.

(c) The steel shall be vacuum degassed before or during the pouring of the ingot or continuous casting as applicable, in order to remove objectionable gases, particularly hydrogen.

(d) The yield strength values, S_y , shall be those shown in Table 1 or Table 1M.

(e) The tensile strength values, S_u , shall be those shown in Table 2 or Table 2M.

(f) This Case number shall be shown on the material marking and documentation, and the Manufacturer's Data Report.

Table 1
Yield Strength Values

Specification No., Grade, Class	Yield Strength, S_y , ksi, for Metal Temperature Not Exceeding, °F								
	100	150	200	250	300	400	500	600	650
ASTM A372/A372M, Grade N, Class 100	100.0	97.5	96.0	94.6	93.5	91.9	90.6	88.9	87.6
ASTM A372/A372M, Grade P, Class 100	100.0	97.5	96.0	94.6	93.5	91.9	90.6	88.9	87.6
ASTM A372/A372M, Grade N, Class 120	120.0	117.0	115.2	113.6	112.2	110.3	108.8	106.7	105.2
ASTM A372/A372M, Grade P, Class 120	120.0	117.0	115.2	113.6	112.2	110.3	108.8	106.7	105.2

Table 1M
Yield Strength Values

Specification No., Grade, Class	Yield Strength, S_y , MPa, for Metal Temperature Not Exceeding, °C												
	40	65	100	125	150	175	200	225	250	275	300	325	350 [Note (1)]
ASTM A372/A372M, Grade N, Class 100	689	673	660	651	644	639	634	630	626	622	617	610	601
ASTM A372/A372M, Grade P, Class 100	689	673	660	651	644	639	634	630	626	622	617	610	601
ASTM A372/A372M, Grade N, Class 120	827	807	792	782	773	767	761	757	752	747	740	733	722
ASTM A372/A372M, Grade P, Class 120	827	807	792	782	773	767	761	757	752	747	740	733	722

NOTE: (1) The maximum design temperature for these materials is 343°C. Values above 343°C are provided only for the purpose of interpolation.

Table 2
Tensile Strength Values

Specification No., Grade, Class	Tensile Strength, S_u , ksi, for Metal Temperature Not Exceeding, °F						
	100	200	300	400	500	600	650
ASTM A372/A372M, Grade N, Class 100	115.0	115.0	115.0	115.0	115.0	115.0	113.2
ASTM A372/A372M, Grade P, Class 100	115.0	115.0	115.0	115.0	115.0	115.0	113.2
ASTM A372/A372M, Grade N, Class 120	135.0	135.0	135.0	135.0	135.0	135.0	132.9
ASTM A372/A372M, Grade P, Class 120	135.0	135.0	135.0	135.0	135.0	135.0	132.9

Table 2M
Tensile Strength Values

Specification No., Grade, Class	Tensile Strength, S_u , MPa, for Metal Temperature Not Exceeding, °C							
	40	100	150	200	250	300	325	350 [Note (1)]
ASTM A372/A372M, Grade N, Class 100	793	793	793	793	793	793	790	776
ASTM A372/A372M, Grade P, Class 100	793	793	793	793	793	793	790	776
ASTM A372/A372M, Grade N, Class 120	931	931	931	931	931	931	928	911
ASTM A372/A372M, Grade P, Class 120	931	931	931	931	931	931	928	911

NOTE: (1) The maximum design temperature for these materials is 343°C. Values above 343°C are provided only for the purpose of interpolation.

Case 2909-1

Supply of Dimpled or Embossed Panels in the Unpillowed Condition

Section VIII, Division 1

Approval Date: July 2, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may panel assemblies, constructed in accordance with Section VIII, Division 1, Mandatory Appendix 17, para. 17-1(a)(2), be supplied without final pillowing as U parts by a Certificate Holder, to subsequently be pillowed to achieve final form by another Certificate Holder incorporating the panel into the final vessel?

Reply: It is the opinion of the Committee that panel assemblies constructed in accordance with Section VIII, Division 1, Mandatory Appendix 17, para. 17-1(a)(2) may be supplied without final pillowing as U parts by a Certificate Holder, to subsequently be pillowed to achieve final form by another Certificate Holder incorporating the panel into the final vessel under the following conditions:

(a) If the panel is to be shaped into a formed head or conical transition, the dimpled region shall not encroach upon the knuckle.

(b) The panel assemblies shall be certified on a Manufacturer's Partial Data Report as described in UG-120(c), with the following additional information included in the Remarks section:

(1) statement by the Part Manufacturer taking responsibility for the design

(2) MAWP of the panel assembly in its final pillowed configuration, as established by the Part Manufacturer through proof testing as provided in Mandatory Appendix 17

(c) The Part Manufacturer shall document and communicate the following parameters to the vessel Manufacturer for applying the pillowing process to the panel assembly to achieve its final form:

(1) minimum rolling radius

(2) rolling direction and orientation

(3) rate of pressurization

(4) maximum forming pressure

(5) maximum pillow height

(d) The vessel Manufacturer shall document the pillowing process, including the application of the specified parameters, and shall make the document available for review by the Authorized Inspector or Certified Individual.

(e) The Authorized Inspector or Certified Individual for the vessel Manufacturer shall be informed of the pertinent parameters of the pillowing operation by the Part Manufacturer, and shall inspect the final pillowed form of the panel assembly for acceptability prior to authorizing application of the Certification Mark to the completed vessel.

(1) If the Authorized Inspector or Certified Individual is not satisfied that the pillowing process has been completed following the Part Manufacturer's parameters in an acceptable manner, the Part stamped nameplate shall be removed and destroyed, and the panel assembly shall no longer be considered acceptable for incorporation into the completed vessel.

(2) If the Authorized Inspector or Certified Individual is satisfied that the pillowing process has been completed in an acceptable manner, the Part stamped nameplate shall remain attached to the completed vessel to ensure traceability to the Manufacturer's Partial Data Report.

(f) The completed vessel shall be documented on a Manufacturer's Data Report or Manufacturer's Certificate of Compliance with additional information included in the Remarks section to document the acceptance of the final pillowing process.

(g) A copy of the Manufacturer's Data Report or Certificate of Compliance shall be provided to the Part Manufacturer.

(h) This Case number shall be shown on the Manufacturer's Partial Data Report and the Manufacturer's Data Report or Manufacturer's Certificate of Compliance.

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Case 2910

Use of SA-693, Grades 630 and XM-12, Classes H1150, H1100, H1075, and H1025

Section VIII, Division 3

Approval Date: March 5, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-693, Grades 630 and XM-12, Classes H1150, H1100, H1075, and H1025 be used for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that SA-693, Grades 630 and XM-12, Classes H1150, H1100, H1075, and H1025 may be used for Section VIII, Division 3 construction, provided the following requirements are met:

(a) The design temperature shall not exceed 550°F (288°C).

(b) The actual measured yield strength for these materials shall not be greater than 25 ksi (172 MPa) above the minimum specified value.

(c) Caution is advised when using materials in Classes H1075 and H1025 as they are more susceptible than lower strength materials to environmental stress corrosion cracking and/or embrittlement due to hydrogen exposure. This susceptibility increases as yield strength increases. The designer shall consider these effects and

their influence on the vessel. See Section II, Part D, Non-mandatory Appendix A, A-330.

(d) Materials in Class H1025 shall not be used for applications if the material, when loaded, is in contact with water or an aqueous environment.

(1) These materials are permitted if they are protected from contact by water or an aqueous environment.

(2) This restriction does not apply to components that are in hydrostatic compression during all loading cycles. Hydrostatic compression is assumed to exist if the sum of the three principal stresses is negative (compressive) at all locations within the component.

(3) This restriction does not apply to inner layers in a vessel whose design meets the leak-before-burst criteria of KD-141.

(e) Materials in Class H1025 may be used under the provisions of Code Case 2793.

(f) The yield strength values, S_y , shall be those shown in [Table 1](#) or [Table 1M](#).

(g) The tensile strength values, S_u , shall be those shown in [Table 2](#) or [Table 2M](#).

(h) This Case number shall be shown on the material marking and documentation, and the Manufacturer's Data Report.

Table 1
Values of Yield Strength, ksi

Specification No., Grade, Class	Yield Strength, S_y , ksi, for Metal Temperature Not Exceeding, °F							
	100	150	200	250	300	400	500	600 [Note (1)]
SA-693, Grade 630, Class H1150	105.0	99.7	97.1	94.9	93.0	89.7	87.0	84.7
SA-693, Grade XM-12, Class H1150	105.0	99.7	97.1	94.9	93.0	89.7	87.0	84.7
SA-693, Grade 630, Class H1100	115.0	109.2	106.3	103.9	101.8	98.3	95.2	92.7
SA-693, Grade XM-12, Class H1100	115.0	109.2	106.3	103.9	101.8	98.3	95.2	92.7
SA-693, Grade 630, Class H1075	125.0	118.7	115.6	113.0	110.7	106.8	103.5	100.8
SA-693, Grade XM-12, Class H1075	125.0	118.7	115.6	113.0	110.7	106.8	103.5	100.8
SA-693, Grade XM-12, Class H1025	145.0	137.7	134.1	131.0	128.4	123.9	120.1	116.9
SA-693, Grade XM-12, Class H1025	145.0	137.7	134.1	131.0	128.4	123.9	120.1	116.9

NOTE: (1) The maximum design temperature for these materials is 550°F. Values above 550°F are provided only for the purpose of interpolation.

Table 1M
Values of Yield Strength, MPa

Specification No., Grade, Class	Yield Strength, S_y , MPa, for Metal Temperature Not Exceeding, °C										
	40	65	100	125	150	175	200	225	250	275	300 [Note (1)]
SA-693, Grade 630, Class H1150	724	688	666	652	641	630	620	611	603	595	588
SA-693, Grade XM-12, Class H1150	724	688	666	652	641	630	620	611	603	595	588
SA-693, Grade 630, Class H1100	793	754	729	714	701	690	680	669	660	651	644
SA-693, Grade XM-12, Class H1100	793	754	729	714	701	690	680	669	660	651	644
SA-693, Grade 630, Class H1075	862	819	793	777	763	750	738	727	717	708	700
SA-693, Grade XM-12, Class H1075	862	819	793	777	763	750	738	727	717	708	700
SA-693, Grade 630, Class H1025	1000	960	918	899	885	870	857	844	832	822	811
SA-693, Grade XM-12, Class H1025	1000	960	918	899	885	870	857	844	832	822	811

NOTE: (1) The maximum design temperature for these materials is 288°C. Values above 288°C are provided only for the purpose of interpolation.

Table 2
Values of Tensile Strength, ksi

Specification No., Grade, Class	Tensile Strength, S_u , ksi, for Metal Temperature Not Exceeding, °F					
	100	200	300	400	500	600 [Note (1)]
SA-693, Grade 630, Class H1150	135.0	135.0	135.0	131.2	128.6	126.7
SA-693, Grade XM-12, Class H1150	135.0	135.0	135.0	131.2	128.6	126.7
SA-693, Grade 630, Class H1100	140.0	140.0	140.0	136.1	133.4	131.4
SA-693, Grade XM-12, Class H1100	140.0	140.0	140.0	136.1	133.4	131.4
SA-693, Grade 630, Class H1075	145.0	145.0	145.0	140.9	138.2	136.1
SA-693, Grade XM-12, Class H1075	145.0	145.0	145.0	140.9	138.2	136.1
SA-693, Grade 630, Class H1025	155.0	155.0	155.0	150.7	147.7	145.5
SA-693, Grade XM-12, Class H1025	155.0	155.0	155.0	150.7	147.7	145.5

NOTE: (1) The maximum design temperature for these materials is 550°F. Values above 550°F are provided only for the purpose of interpolation.

Table 2M
Values of Tensile Strength, MPa

Specification No., Grade, Class	Tensile Strength, S_u , MPa, for Metal Temperature Not Exceeding, °C					
	40	100	150	200	250	300 [Note (1)]
SA-693, Grade 630, Class H1150	931	931	931	907	889	877
SA-693, Grade XM-12, Class H1150	931	931	931	907	889	877
SA-693, Grade 630, Class H1100	965	965	965	941	922	910
SA-693, Grade XM-12, Class H1100	965	965	965	941	922	910
SA-693, Grade 630, Class H1075	1000	1000	1000	974	955	943
SA-693, Grade XM-12, Class H1075	1000	1000	1000	974	955	943
SA-693, Grade 630, Class H1025	1069	1069	1069	1041	1021	1007
SA-693, Grade XM-12, Class H1025	1069	1069	1069	1041	1021	1007

NOTE: (1) The maximum design temperature for these materials is 288°C. Values above 288°C are provided only for the purpose of interpolation.

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Case 2911-1

Alternative Method of Vessel Markings

Section VIII, Division 1; Section VIII, Division 2

Approval Date: February 7, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Section VIII, Division 1, UG-118 and Section VIII, Division 2, 2-F.5(b)(1) require marking including the ASME Certification Mark, per Section VIII, Division I, UG-116 and Section VIII, Division 2, 2-F.1, to be stamped directly on the vessel or on a separate nameplate. May a Certificate Holder mechanically etch the required markings in UG-116 and 2-F.1 on the external surfaces of a vessel or vessel part as an alternative to the requirements in UG-118 and 2-F.5(b)(1)?

Reply: It is the opinion of the Committee that a Certificate Holder may apply the required markings including the ASME Certification Mark in ASME CA-1, Figure 1 and Section VIII, Division 1, UG-116 and Section VIII, Division 2, 2-F.5(b)(1) to the external surfaces of a vessel or vessel part by mechanical etching, provided the following requirements are met:

(a) Marking does not result in any detrimental effect to materials of the vessel or vessel part.

(b) The data shall be in characters not less than $\frac{5}{16}$ in. (8 mm) high and shall be readable. The character size may be reduced as shown in the following table for small diameter vessels or vessel parts with space limitations:

Nominal Outside Vessel or Vessel Part Diameter, in. (mm)		Minimum Character Size, in. (mm)
Minimum	Maximum	
...	$3\frac{1}{2}$ (89)	$\frac{1}{8}$ (3)
$> 3\frac{1}{2}$ (> 89)	$4\frac{1}{2}$ (114)	$\frac{3}{16}$ (5)
$> 4\frac{1}{2}$ (> 114)	$6\frac{5}{8}$ (168)	$\frac{1}{4}$ (6)

(c) The mechanical etching process shall be automated and utilize a stressless (soft) stamping or etching method.

(d) The process controls for mechanical etching shall be described in the Quality Control System and shall be acceptable to the Authorized Inspector. The process controls shall be established so that it can be demonstrated that the characters will be at least 0.004 in. (0.1 mm) deep.

(e) The external vessel-surface condition where mechanical etching is acceptable shall be clean, uncoated, and unpainted.

(f) The materials are limited to high-alloy steels and nonferrous materials.

(g) The minimum thickness of the vessel or vessel part shall not be less than $\frac{1}{8}$ in. (3 mm).

(h) Mechanical etching shall be arranged substantially as shown in Figure UG-118 when space permits and shall be located in a conspicuous place on the vessel or vessel part [see UG-116 or 2-F.5(b)(1)].

(i) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2912

Alternate Rules for Quick-Actuating Closures

Section VIII, Division 1

Approval Date: March 5, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a quick-actuating closure be designed in lieu of the requirements in UG-35.2(b)(2)?

Reply: It is the opinion of the Committee that a quick-actuating closure may be designed in lieu of the requirements in UG-35.2(b)(2), provided the following requirements are met:

(a) Quick-actuating closures shall be designed such that the failure of a single locking element while the vessel is pressurized (or contains a static head of liquid acting at the closure) will not

(1) cause or allow the closure to be opened or to leak
(2) result in the failure of any other locking element or holding element

(3) increase the stress in any other locking element or holding element by more than 50% above the allowable stress of the element

(b) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2914

30Cr-7Ni-3.5Mo-N, UNS S83071, Austenitic-Ferritic Stainless Steel

Section VIII, Division 1; Section VIII, Division 2

Approval Date: March 5, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed UNS S83071 seamless pipe and tube with the chemical composition conforming to [Table 1](#), mechanical properties conforming to [Table 2](#), and otherwise conforming to the respective requirements of the specifications in [Table 3](#), be used for welded construction under the rules of Section VIII, Division 1 and 2?

Reply: It is the opinion of the Committee that solution annealed UNS S83071 seamless pipe and tube as described in the Inquiry may be used in welded construction under the rules of Section VIII, Division 1 and 2, provided the following requirements are met:

(a) The maximum design temperature shall be 600°F (316°C).

(b) The material shall be heat treated at a temperature of 1,830°F to 2,100°F (1,000°C to 1,150°C) followed by rapid cooling in water or by other means.

(c) For external pressure design, Section II, Part D, Figure HA-5 and Table HA-5 shall apply.

(d) For Section VIII, Division 1, the maximum allowable stress values for the material shall be those in [Table 4](#) and [Table 4M](#).

(e) For Section VIII, Division 2, Class 1, the maximum allowable stress values for the material shall be those in [Table 5](#) and [Table 5M](#).

(f) For Section VIII, Division 2, Class 2, the maximum allowable stress values for the material shall be those in [Table 6](#) and [Table 6M](#).

(g) Separate welding procedure qualifications and performance qualifications, conducted in accordance with Section IX, shall be required for this material.

(h) The yield strength and tensile strength values are shown in [Tables 7](#) and [7M](#).

(i) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of [\(b\)](#) shall apply.

(j) The physical properties as follows shall apply:

(1) Density is 0.2797 lb/in.³ (7.741 g/cm³).

(2) Thermal expansion is shown in [Tables 8](#) and [8M](#).

(3) Thermal conductivity and thermal diffusivity are shown in [Tables 9](#) and [9M](#).

(4) The modulus of elasticity and Poisson's ratio are shown in [Tables 10](#) and [10M](#).

(k) For Division 2 fatigue analysis, this material shall be considered Table 3-F.3 material.

(l) The rules in Section VIII, Division 1, Subsection C that shall apply are those in Part UHA for austenitic-ferritic duplex stainless steels. For Section VIII, Division 2, Class 1 and Class 2 applications, the rules for austenitic-ferritic duplex stainless steels shall apply.

(m) This Case number shall be shown in the marking, on the certification of the material, and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition Limit, %
Carbon	0.030 max.
Manganese	0.50–1.50
Phosphorus	0.030 max.
Sulfur	0.020 max.
Silicon	0.50 max.
Chromium	29.0–31.0
Nickel	6.0–8.0
Molybdenum	3.0–4.0
Copper	0.80 max.
Nitrogen	0.28–0.40

Table 2
Mechanical Test Requirements (Room Temperature)

Mechanical Property	Requirement
Tensile strength, min., ksi (MPa)	120 (830)
Yield Strength, 0.2% offset, min., ksi (MPa)	98 (680)
Elongation, 2 in. (50 mm), min., %	25

**Table 3
Product Specifications**

Product	Specification
Seamless pipe	SA-790
Seamless tube	SA-789

**Table 4
Maximum Allowable Stress Values, ksi, Section VIII,
Division 1**

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi
100	33.4
200	33.5
300	33.5
400	33.5
500	33.5
600	33.5

GENERAL NOTE: This steel may be expected to develop embrittlement after service at moderately elevated temperature; see Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

**Table 4M
Maximum Allowable Stress Values, MPa, Section VIII,
Division 1**

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa
40	237
65	236
100	230
150	230
200	230
250	230
300	230
350 [Note (1)]	230

GENERAL NOTE: This steel may be expected to develop embrittlement after service at moderately elevated temperature; see Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

NOTE: (1) This value is provided for interpolation purposes only. The maximum use temperature is 316°C.

**Table 5
Maximum Allowable Stress Values, ksi, Section VIII,
Division 2, Class 1**

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi
100	41.0
200	39.0
300	38.9
400	38.9
500	38.9
600	38.9

GENERAL NOTE: This steel may be expected to develop embrittlement after service at moderately elevated temperature; see Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

**Table 5M
Maximum Allowable Stress Values, MPa, Section VIII,
Division 1**

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa
40	277
100	269
150	268
200	268
250	268
300	268
350 [Note (1)]	268

GENERAL NOTE: This steel may be expected to develop embrittlement after service at moderately elevated temperature; see Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

NOTE: (1) This value is provided for interpolation purposes only. The maximum use temperature is 316°C.

Table 6
Maximum Allowable Stress Values, ksi, Section VIII, Division 2, Class 2

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi
100	50.2
200	50.2
300	50.1
400	50.0
500	49.1
600	47.4

GENERAL NOTE: This steel may be expected to develop embrittlement after service at moderately elevated temperature; see Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

Table 6M
Maximum Allowable Stress Values, MPa, Section VIII, Division 2, Class 2

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress, MPa
40	346
100	346
150	345
200	345
250	340
300	330
350 [Note (1)]	321

GENERAL NOTE: This steel may be expected to develop embrittlement after service at moderately elevated temperature; see Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

NOTE: (1) This value is provided for interpolation purposes only. The maximum use temperature is 316°C.

Table 7
Yield Strength, ksi, and Tensile Strength, ksi, Values

For Metal Temperature Not Exceeding, °F	Maximum Yield Strength, ksi [Note (1)]	Maximum Tensile Strength, ksi [Note (2)]
100	98.6	120.4
200	77.7	117.1
300	75.1	117.1
400	75.0	117.1
500	73.7	117.1
600	71.0	117.1

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, Note (b) applies to these values.
- (2) Section II, Part D, Subpart 1, Table U, Note (b) applies to these values.

Table 7M
Yield Strength, MPa, and Tensile Strength, MPa, Values

For Metal Temperature Not Exceeding, °C	Maximum Yield Strength, MPa [Note (1)]	Maximum Tensile Strength, MPa [Note (2)]
40	680	830
100	531	806
150	518	809
200	517	809
250	510	809
300	495	809
350	481	809

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, Note (b) applies to these values.
- (2) Section II, Part D, Subpart 1, Table U, Note (b) applies to these values.

Table 8
Thermal Expansion, in./in./°F × 10⁻⁶

Temperature Range, °F	Value, in./in./°F × 10 ⁻⁶
86-122	6.4
86-212	6.7
86-302	6.9
86-392	7.1
86-482	7.2
86-572	7.3
86-662	7.4
86-752	7.5

Table 8M
Thermal Expansion, mm/mm/°C × 10⁻⁶

Temperature Range, °C	Value, mm/mm/°C × 10 ⁻⁶
30-50	11.5
30-100	12.1
30-150	12.4
30-200	12.7
30-250	12.9
30-300	13.1
30-350	13.3
30-400	13.5

Table 9
Thermal Conductivity, Btu/hr ft °F, and Thermal Diffusivity, ft²/hr

Temperature, °F	Thermal Conductivity, Btu/hr ft °F	Thermal Diffusivity, ft ² /hr
73	7.1	0.132
122	7.5	0.136
212	8.0	0.141
302	8.6	0.145
392	9.1	0.150
482	9.7	0.153
572	10.2	0.157
662	10.8	0.160
752	11.3	0.164

Table 9M
Thermal Conductivity, W/m °C, and Thermal Diffusivity, mm²/s × 10⁻⁶

Temperature, °C	Thermal Conductivity, W/m °C	Thermal Diffusivity, mm ² /s × 10 ⁻⁶
23	12.3	3.41
50	12.9	3.51
100	13.9	3.64
150	14.8	3.75
200	15.8	3.86
250	16.7	3.96
300	17.6	4.05
350	18.6	4.14
400	19.6	4.22

Table 10
Modulus of Elasticity, ksi ×10³, and Poisson's Ratio

Temperature, °F	Modulus of Elasticity, ksi ×10 ³	Poisson's Ratio
68	27.7	0.39
122	27.4	0.39
212	26.8	0.40
302	26.3	0.41
392	25.8	0.42
482	25.2	0.43
572	24.7	0.44
662	24.1	0.45
752	23.6	0.46

Table 10M
Modulus of Elasticity, MPa ×10³, and Poisson's Ratio

Temperature, °C	Modulus of Elasticity, MPa ×10 ³	Poisson's Ratio
20	191	0.39
50	189	0.39
100	185	0.40
150	181	0.41
200	178	0.42
250	174	0.43
300	170	0.44
350	166	0.45
400	163	0.46

Case 2916

Use of ASTM B834-15, Pressure Consolidated Powder Metallurgy

Section I

Approval Date: April 6, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May pressure consolidated powder metallurgy material to ASTM B834-15 be used in all types of pipe flanges, fittings, valves, and parts manufactured for Section I construction?

Reply: It is the opinion of the Committee that pressure consolidated powder metallurgy material to ASTM B834-15 may be used in all types of pipe flanges, fittings, valves, and parts manufactured for Section I construction, provided the following requirements are met:

(a) Maximum use temperature shall not exceed that shown in [Table 1](#).

(b) Allowable stress values to be used shall be those in Table 1B of Section II, Part D, for Section I use for SB-166, alloy UNS N06600; SB-167, alloy UNS N06690; SB-446, alloy UNS N06625 (Grades 1 and 2); SB-691, alloy N08367. In the case of UNS N07718, the allowable stress values contained in [Tables 2](#) and [2M](#) shall be used.

(c) The maximum allowable powder size shall be 0.020 in. (0.5 mm), and the powder shall be produced by the gas atomization process. Immediately following atomization, the powder shall remain shielded by an inert gas until it is below a temperature of 105°F (40°C) to ensure that the detrimental absorption of oxygen and other deleterious contaminants is no longer possible. Following atomization, powders should be protected during storage to prevent the detrimental pick-up of oxygen and other contaminants.

(d) Analysis for chemical composition as noted in ASTM B834-15 is mandatory. A representative sample of each blend of powder shall be analyzed by the manufacturer to determine the percentage of elements prescribed in Table 1 of ASTM B834-15. The blend shall conform to the chemical composition requirements prescribed in Table 1 of ASTM B834-15.

(e) A product analysis shall be a mandatory requirement. The chemical composition of a sample from one part from each lot of parts shall be determined by the manufacturer. The composition of the sample shall conform to the chemical requirements prescribed in Table 1 of ASTM B834-15.

(f) For the mechanical properties as shown in Table 3 of ASTM B834-15, it is acceptable for the test sample to be from the component, stem, protrusion, or test part made from a single powder blend consolidated in the same hot isostatic press using the same pressure, temperature, time parameters, and heat-treated in the same final heat treatment charge.

(g) The P-No. to be used in welding these materials shall be considered the same as the P-No. of the material and specification in [Table 1](#). For alloy UNS N07718, separate welding procedure and performance qualifications shall be conducted in accordance with Section IX. Welding of UNS N07718 shall be limited to the gas tungsten arc welding (GTAW) process. Re-aging shall be done with the heat treatment as listed in ASTM B834-15.

(h) A microstructural examination shall be mandatory. The compact shall be sectioned and the microstructure examined to check for porosity and other internal imperfections. The microstructure when examined at 20× to 50×, 100× to 200×, and 1,000× to 2,000× shall be reasonably uniform and shall be free of voids, laps, cracks, and porosity. One sample from each production lot shall be examined. The sample, at the option of the producer, shall be taken after hot-isostatic pressing or after final heat treatment. If the sample fails to meet the requirements for acceptance, each part in the lot is permitted to be retested, at the option of the producer, and those that pass shall be accepted. The sample shall be from the component, stem, protrusion, or test part made from a single powder blend following the same manufacturing process.

(i) The use of the product standard pressure-temperature ratings (PG-42.1) is not permitted unless this material is specifically listed in the applicable standard or Case relating to that standard. Parts shall be rated in accordance with the manufacturer's standard per PG-11.4.1.

(j) A Manufacturer's Certification shall be furnished to the purchaser stating that material has been manufactured, tested, and inspected in accordance with this Case and that the test results on representative samples meet specification requirements. A report of the test results shall be furnished.

(k) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry, and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a

sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g. chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe under deposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

**Table 1
Maximum Use Temperature**

ASME Specification to Be Used for Allowable Stress Values and P-No.	UNS Number	Temper	Temperature, °F (°C)	P-Number
SB-166	N06600	Annealed [Note (1)]	850 (454)	43
SB-167	N06690	Annealed [Note (2)]	900 (482)	43
SB-446	N06625	Annealed [Note (3)]	1,100 (593)	43
SB-446	N06625	Solution annealed [Note (4)]	1,150 (621)	43
SB-637	N07718	Solution annealed and aged [Note (5)]	1,100 (593)	None, see para. (g)
SB-691	N08367	Solution annealed [Note (6)]	800 (427)	45

NOTES:

- (1) 1,850°F (1 010°C) min.
- (2) 1,900°F (1 040°C) min.
- (3) 1,925°F (1 050°C) min.
- (4) 2,000°F (1 095°C) min.
- (5) 1,325°F ± 25°F (718°C ± 14°C) — hold at temperature for 8 hr, furnace cool to 1,150°F ± 25°F (621°F ± 14°C), hold until total precipitation heat treatment time has reached 18 hr, and air cooled.
- (6) 2,025°F (1 105°C) min.

**Table 2
Maximum Allowable Stress Values, ksi, for UNS N07718**

For Metal Temperature, Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	52.9
200	52.9
300	52.9
400	52.9
500	52.9
600	52.3
650	52.0
700	51.8
750	51.7
800	51.6
850	51.5
900	51.4
950	51.1
1,000	50.7
1,050	50.1
1,100	49.3

**Table 2M
Maximum Allowable Stress Values, MPa, for UNS N07718**

For Metal Temperature, Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	364
65	364
100	364
150	364
200	364
250	364
275	364
300	362
325	360
350	358
375	357
400	356
425	356
450	355
475	354
500	353
525	351
550	348
575	344
600 [Note (1)]	333

NOTE: (1) These values are provided at 600°C for interpolation use only. The maximum use temperature is 593°C.

Case 2917

ASTM A1091/A1091M-16, Grade C91 Castings

Section I

Approval Date: June 19, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May ASTM A1091/A1091M-16, Grade C91 castings be used in Section I welded construction?

Reply: It is the opinion of the Committee that ASTM A1091/A1091M-16, Grade C91 castings may be used in Section I welded construction, provided that the following additional requirements are met:

(a) The y -coefficient for this material shall be that applicable to ferritic materials in PG-27.4.6.

(b) The tensile strength values, S_u , and the yield strength values, S_y , shall be those given in [Table 1](#) and [Table 1M](#).

(c) The maximum allowable stress values shall be those given in [Table 2](#) and [Table 2M](#).

(d) The maximum design temperature is 1,200°F (649°C).

(e) For external pressure, Figure CS-3 in Section II, Part D, Subpart 3 shall be used.

(f) For physical properties, those given in Section II, Part D, Subpart 2, for Grade 91 shall be used.

(g) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. This material shall be considered P-No. 15E, Group 1.

(h) For major weld repairs to the castings, in any orientation, in accordance with ASTM A1091/A1091M-16, the allowable stress values shall be reduced using the weld strength reduction factors given in PG-26 and Table PG-26 for CSEF Steels.

(i) For minor weld repairs to the castings in accordance with ASTM A1091/A1091M-16, the allowable stress values shall be those given in [Table 2](#) and [Table 2M](#).

(j) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Tensile Strength, S_u , and Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °F	S_u Values, ksi [Note (1)]	S_y Values, ksi [Note (2)]
100	85.0	60.0
150	...	57.5
200	85.0	56.3
250	...	55.4
300	82.3	54.8
350	...	54.2
400	79.8	53.9
450	...	53.5
500	77.9	53.3
550	...	53.0
600	75.9	52.6
650	74.7	52.2
700	73.4	51.6
750	71.8	50.8
800	69.8	49.7
850	67.6	48.4
900	64.9	46.8
950	61.8	44.8
1,000	58.2	42.4

NOTES:

- (1) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond to "average" as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to "minimum" or "average," as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 1M
Tensile Strength, S_u , and Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °C	S_u Values, MPa [Note (1)]	S_y Values, MPa [Note (2)]
40	586	414
65	...	396
100	586	387
125	...	381
150	567	377
175	...	374
200	551	372
225	...	370
250	539	368
275	...	366
300	527	364
325	521	362
350	513	359
375	504	355
400	494	350
425	482	343
450	469	335
475	453	326
500	434	314
525	413	300

NOTES:

- (1) The tabulated values of tensile strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value that may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

**Table 2
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	24.3
200	24.3
300	23.5
400	22.8
500	22.2
600	21.7
650	21.4
700	21.0
750	20.5
800	20.0
850	19.3
900	18.5
950	17.7
1,000	14.3
1,050	11.3
1,100	8.6
1,150	5.7
1,200	3.5

**Table 2M
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	167
65	167
100	167
125	165
150	162
200	158
250	154
300	151
325	149
350	147
375	144
400	141
425	138
450	134
475	129
500	124
525	109
550	89.2
575	71.1
600	54.3
625	36.8
650 [Note (1)]	24.0

NOTE: (1) The maximum design temperature is 649°C. The value provided at 650°C is for interpolation purposes only.

Case 2918

Alternative Fiber for Class 1 Fabrication

Section X

Approval Date: January 18, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an alternative fiber complying with the requirements of Section X, RM-111, RM-112, or RM-113 be substituted for the original fiber for fabrication of Section X, Class 1 pressure vessels?

Reply: It is the opinion of the Committee that an alternative fiber complying with Section X, RM-111, RM-112, or RM-113 may be substituted for the original fiber for fabrication of filament-wound Class 1 pressure vessels, provided the following requirements are met:

(a) This Case is restricted to the fabrication of Section X, Class 1 filament-wound vessels.

(b) *Definitions*

original fiber: the fiber originally qualified per Article RQ-4 and Article RT-2.

alternative fiber: a fiber of the same composition as the original fiber complying with RM-111, RM-112, or RM-113.

(c) Qualification of the alternative fiber and use of the fiber for production vessels shall comply with all requirements of Section X, except as permitted in this Case.

(d) *Alternative Fiber Requirements*

(1) The surface of the alternative fiber shall be treated in accordance with RM-114.

(2) The minimum tensile strength of the alternative fiber shall equal or exceed the minimum tensile strength of the original fiber.

(3) *Alternative fiber modulus of elasticity*

(-a) When the alternative fiber completely replaces the original fiber, the nominal modulus of elasticity shall be within 10% of the value of the original fiber modulus.

(-b) When the alternative fiber and the original fiber are combined in any ratio in the laminate, the modulus of elasticity of the alternative fiber shall be within 5% of the original fiber modulus.

(e) *Qualification of Alternative Fiber*

(1) The alternative fiber qualification test vessels shall be fabricated per the original fiber filament-winding procedure except for the substitution of the alternative fiber for the original fiber.

(2) The diameter of fiber used in the alternative fiber qualification test vessels shall be the same diameter as the original fiber used in the prototype vessels.

(3) The alternative fiber shall be qualified by a hydrostatic pressure test in accordance with RT-223.1(b).

(4) The secondary fiber shall be qualified per (3) in the longest and shortest vessels of the design series.

(5) Nozzles and openings required in the original fiber prototype vessels may be omitted from the alternative fiber qualification test vessels.

(f) *Alternative Fiber Use.* Upon successful qualification, the alternative fiber may be used in lieu of the original fiber without further testing subject to the following:

(1) The alternative fiber and original fiber may be combined in any ratio, or the alternative fiber only may be used in the original fiber winding procedure subject to (d)(3).

(2) The resin shall be as specified in the original fiber winding procedure.

(3) Laminate thickness shall be within 5% of the qualified nominal laminate thickness for the original fiber.

(g) A reduced testing program may be used when substituting the alternative fiber for the original fiber in similar existing vessel designs subject to the following:

(1) *Design Pressure.* An increase in design pressure above the original fiber qualified design pressure is prohibited. A design pressure less than 50% of the qualified design pressure is prohibited.

(2) *Length.* Qualification testing is not required for lengths between the longest and shortest qualified.

(3) *Diameter.* Restricted to the qualified vessel diameter for the original fiber.

(h) Supplemental documentation identifying the manufacture's name and designation for the alternative fiber shall be added to the original qualified filament-winding procedure.

(i) Use of an alternative fiber to the original fiber shall be acceptable to the Authorized Inspector.

(j) This Case number shall be shown on the Fabricator's Data Report.

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Case 2919-1

Volumetric Expansion Tests

Section X

Approval Date: August 5, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to accept a volumetric expansion test result other than 105% of the value recorded in the original Qualification Test Report and Procedure Specification, for a Section X, Class I pressure vessel per RT-330, provided all other requirements of Section X have been met?

Reply: It is the opinion of the Committee that Fabricators of Class I pressure vessels may accept a volumetric expansion test result other than 105% of the value recorded in

the original Qualification Test Report and Procedure Specification per RT-330, provided the following requirements are met:

(a) The volumetric expansion shall not be greater than 110% of the value recorded in the original Qualification Test Report and Procedure Specification.

(b) This Case shall only apply to the Fabrication Method of Filament-Winding Process per Article RF-4.

(c) The volumetric expansion shall not exceed 10 gal (37.85 L).

(d) No visual delamination between the liner and fiberglass the filament wound structural layer is allowed per Mandatory Appendix 6, Table 6-100.1.

(e) This Case number shall be recorded on Fabricator's Data Report.

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Case 2920

Frequency of Determination of Weight of Resin and Fiber

Section X

Approval Date: January 18, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to extend the frequency of determination of weight of resin and fiber beyond once a year for a Section X, Class I pressure vessel per RT-320, provided all other requirements of Section X have been met?

Reply: It is the opinion of the Committee that Fabricators of Class I pressure vessels may extend the frequency of determination of weight of resin and fiber beyond once a

year per RT-320, provided the following requirements are met:

(a) The frequency of determination of weight of resin and fiber shall not exceed 3 yr.

(b) The percent fiber by weight in composite shall be recorded on Form Q-107.

(c) This Case shall only apply to the fabrication method of filament-winding process per Article RF-4.

(d) The Fabricator shall stamp at least 24 vessels per year, for all qualified Procedure Specifications.

(e) One determination of weight of resin and fiber shall be made for every 1,000 duplicate vessels, regardless of the extended time frequency of 3 yr.

(f) This Case number shall be recorded on the appropriate Fabricator's Data Reports.

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Case 2921

Spherical Intermediate Head or End Closure Without Straight Flange

Section XII

Approval Date: May 7, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible to attach a spherical head segment to a cylindrical shell section to form an intermediate head or end closure, as shown in [Figure 1](#), for Section XII construction?

Reply: It is the opinion of the Committee that it is permissible to attach a spherical head segment to a cylindrical shell section to form an intermediate head or end closure, as shown in [Figure 1](#), for Section XII construction, provided the following requirements are met:

(a) Head thickness shall be calculated in accordance with (1) and (2) with P being the maximum differential pressure. For differential pressure design, the common element design pressure shall be the maximum differential design pressure expected between the adjacent chambers. The common element and its corresponding differential pressure shall be indicated in the Remarks section of the Manufacturer's Data Report and marked on the vessel nameplate. The differential pressure shall be controlled to ensure the common element design pressure is not exceeded. The maximum intermediate head dish radius, L , shall be limited to the shell inside diameter.

For head thickness, t

(1) for pressure on concave side

$$t = \frac{5PL}{6SE}$$

where

E = joint efficiency of any joint within the spherical head

S = maximum allowable stress value allowed per TD-210 of Section XII

(2) for pressure on convex side, the head thickness shall be determined based on TD-400.3 using the outside radius of the spherical head segment

(b) The stresses in the area of the head-to-shell joint shall be evaluated by elastic method in accordance with Parts 5.2.2 and 5.3.2 of Section VIII, Division 2. Section XII

allowable stresses shall be used. The cyclic loading conditions shall be evaluated or exempted per Part 5.5 of Section VIII, Division 2.

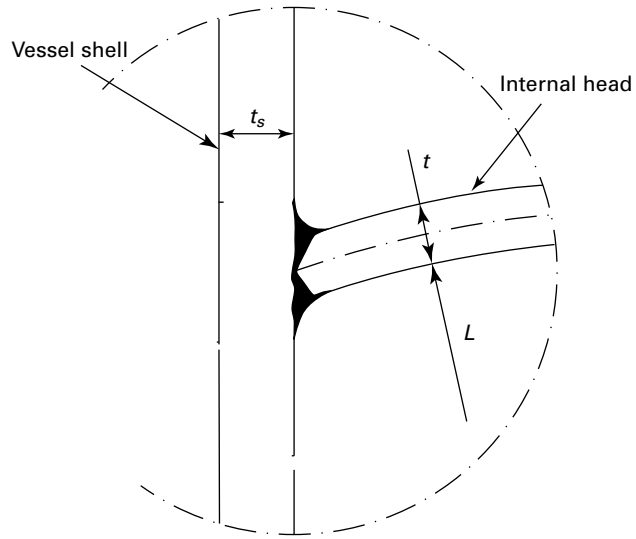
(c) The weld shall be full penetration through the head thickness (see [Figure 1](#)).

(d) When the shell base material is formed from plate, the region 9 in. (230 mm) or $(Rt_s)^{1/2}$, whichever is greater, above and below the weld centerline, shall be ultrasonically examined in accordance with SA-578, and the Level C acceptance criteria shall apply. R and t_s are the shell radius and thickness, respectively. For all shell product forms, the shell at the head-to-shell junction shall be ultrasonically examined to check for lamellar tearing and fusion of weld. Ultrasonic testing is always required. However, if postweld heat treatment (PWHT) is performed, the ultrasonic examination shall be done after any postweld heat treatment (PWHT) in accordance with Mandatory Appendix IX of Section XII. Ultrasonic testing may be exempted for 300 series austenitic stainless steel up to $1/2$ in. (13 mm) thickness.

(e) After welding and any PWHT, the weld joint shall be examined by magnetic particle examination in accordance with Mandatory Appendix V or by liquid penetrant examination in accordance with Mandatory Appendix VI of Section XII.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Full Penetration Weld



Case 2924

Heat-Affected Zone Impact Testing in Weld Procedure Qualification, Para. 3.11.8.2(c)

Section VIII, Division 2

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may welding procedure specification qualified with toughness testing in accordance with the rules of Section VIII, Division 2, 1992 Edition and subsequent editions and addenda, be acceptable for construction without performing additional impact testing to meet the requirements of para. 3.11.8.2(c)?

Reply: It is the opinion of the Committee that welding procedure specifications qualified with toughness testing in accordance with the rules of Section VIII, Division 2, 1992 Edition and subsequent editions and addenda, be acceptable for construction without performing additional impact testing to meet the requirements of para. 3.11.8.2(c), provided the following requirements are met:

(a) The welding procedure specification has been previously qualified and met the requirements of Section VIII, Division 2 prior to the 2017 Edition.

(b) The existing welding procedure specification may be used until the 2021 Edition of Section VIII, Division 2 goes into effect on January 1, 2022.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2926

Use of 1Cr- $\frac{1}{5}$ Mo Seamless Pipe for Pressure Purposes

Section VIII, Division 1

Approval Date: September 19, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may 1Cr- $\frac{1}{5}$ Mo seamless pipe be used for the manufacture of cylindrical pressure vessels?

Reply: It is the opinion of the Committee that the 1Cr- $\frac{1}{5}$ Mo seamless pipe may be used for the manufacture of cylindrical pressure vessels, provided the following requirements are met:

(a) The pipe shall meet all requirements in SA-372 for Grade E Class 70, except for SA-372, para. 4.2.1, and the marking and certification – see also (e) of this Case.

(b) All applicable requirements for SA-372, Grade E, Class 70 in Section VIII, Division 1 shall be met, such as, but not limited to, Part UF and UHT-6.

(c) Welding or brazing is not permitted, including weld repair.

(d) The allowable stresses and temperature limit shall be according to Section II, Part D, Table 1A for SA-372 Grade E, Class 70 for Section VIII, Division 1.

(e) This Case number shall be shown on the marking and certification of the material and on the Manufacturer's Data Report.

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Case 2927

PWHT Exemption When Using Laser Beam Welding to Attach Fins to P-No. 15E Pipe and Tube Materials

Section I

Approval Date: August 1, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May laser beam welding be used to attach extended heat-absorbing fins of weldable quality material to P-No. 15E pipe and tube materials without postweld heat treatment (PWHT)?

Reply: It is the opinion of the Committee that PWHT is not mandatory for laser beam welds used to attach extended heat-absorbing fins of weldable quality to P-No. 15E pipe and tube materials, provided the following requirements are met:

(a) The maximum pipe or tube size shall be NPS 4 (DN 100).

(b) The maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) shall be not more than 0.15%.

(c) The maximum fin thickness shall be $\frac{1}{8}$ in. (3 mm).

(d) Prior to using the welding procedure, the Manufacturer shall demonstrate that the heat-affected zone does not encroach upon the required minimum wall thickness.

(e) The demonstration shall be on a fin welded to a pipe or tube.

(f) In addition to the essential variables listed in Section IX, Table QW-264, the power delivered to the work surface as measured by a calorimeter or other suitable method shall not exceed that used in the demonstration.

(g) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2928

Applicability of ASTM B432 for Construction of Pressure Vessels

Section VIII, Division 1

Approval Date: September 19, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SB-171 UNS C70600 clad to SA-266 carbon steel and produced according to ASTM B432-14 be used in the construction of Section VIII, Division 1 pressure vessels?

Reply: It is the opinion of the Committee that SB-171 UNS C70600 clad to SA-266 carbon steel and produced according to ASTM B432-14 may be used in the construction of Section VIII, Division 1 pressure vessels, provided the following additional requirements are met:

(a) All the rules of Section VIII, Division 1, Part UCL shall apply.

(b) The following sections in ASTM B432-14 are mandatory:

(1) certification: para. 4.2.2 and section 20

(2) test report: para. 4.2.3 and section 21

(3) inspection: section 16

(c) When any part of the cladding is to be included in design calculations, the rules of Section VIII, Division 1, UCL-11(c) shall apply except the minimum shear strength of the interface shall be 12,000 psi (84 MPa). The alternative Bond Strength Test shall be that described in ASTM B432-14, para. 8.1.2.

(d) The maximum use temperature shall be 600°F (316°C).

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2929

Use of SA-36/SA-36M and SA-675/SA-675M, Rectangular Carbon Steel Bars for Stiffening Rings

Section I

Approval Date: August 1, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May SA-36/SA-36M and SA-675/SA-675M, rectangular carbon steel bars be used as stiffening rings in applications currently restricted by Section II, Part D, Table 1A, Note G15?

Reply: It is the opinion of the Committee that SA-36/SA-36M and SA-675/SA-675M, rectangular carbon steel bars may be used for stiffening rings, provided the following requirements are met:

- (a) The requirements of PFT-17 shall be met.*
- (b) All other requirements of Section I shall apply.*
- (c) This Case number shall be shown on the Manufacturer's Data Report.*

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Case 2930

Use of ASTM A988/A988M-17 Hot Isostatically Pressure Consolidated Powder Metallurgy

Section I

Approval Date: August 24, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May hot isostatically-pressed powder material for UNS S30400, UNS S30403, UNS S31600, UNS S31603, UNS S31725, UNS S31254, and UNS N08367 conforming to ASTM A988/A988M-17 be used in all types of pipe flanges and valves, fittings, and parts manufactured for Section I construction?

Reply: It is the opinion of the Committee that hot isostatically-pressed powder material for UNS S30400, UNS S30403, UNS S31600, UNS S31603, UNS S31725, UNS S31254, and UNS N08367 conforming to ASTM A988/A988M-17 may be used in all types of pipe flanges and valves, fittings, and parts manufactured for Section I construction, provided the following requirements are met:

(a) Maximum use temperature shall not exceed that shown in [Table 1](#).

(b) The maximum allowable stress values for UNS S30400, UNS S30403, UNS S31600, UNS S31603, UNS S31725, and UNS S31254 shall be those given in Section II, Part D, Table 1A. The maximum allowable stress values for UNS N08367 shall be those given in Section II, Part D, Table 1B.

(c) Powder should be protected during storage to prevent the detrimental pickup of oxygen and other contaminants.

(d) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. The P-No. assigned for welding these materials shall be the same P-No. as the wrought material specifications given in [Table 1](#).

(e) The fatigue design curves, tensile strength and yield strength values, thermal expansion, and other properties shall be the same as for the material specification given in [Table 1](#).

(f) The component shall be capable of passing an ASTM A262-15, Practice E test.

(g) The use of the product standard pressure-temperature ratings (PG-42.1) is not permitted unless this material is specifically listed in the applicable standard. Parts shall be rated in accordance with the Manufacturer's Standard per PG-11.4.1.

(h) This Case number shall be shown on the Manufacturer's Data Report and identified on the marking and documentation of the material.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition, or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe under deposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
P-Number, Maximum Use Temperature, and Allowable Stresses

ASME Specification to Be Used for Allowable Stress Values and P-Number	UNS Number	Grade	P-Number/ Group No.	Temperature, °F (°C)	Allowable Stresses (Per Section II, Part D)
SA-182/SA-182M	S30400	304	8/1	950 (510)	Table 1A [Size/thickness ≤5 in. (≤125 mm)]
SA-182/SA-182M	S30403	304L	8/1	800 (427)	Table 1A [Size/thickness ≤5 in. (≤125 mm)]
SA-182/SA-182M	S31600	316	8/1	1,000 (538)	Table 1A [Size/thickness ≤5 in. (≤125 mm)]
SA-182/SA-182M	S31603	316L	8/1	850 (454)	Table 1A [Size/thickness ≤5 in. (≤125 mm)]
SA-240/SA-240M	S31725	...	8/4	300 (149)	Table 1A
SA-182/SA-182M	S31254	F44	8/4	750 (399)	Table 1A
SB-564	N08367	...	45	800 (427)	Table 1B

Case 2931

Use of ASTM A989/A989M-15 Hot Isostatically Pressure Consolidated Powder Flanges, Fittings, Valves, and Parts

Section I

Approval Date: August 24, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May hot isostatically-pressed material UNS K90941 conforming to ASTM A989/A989M-15 be used in pipe flanges, fittings, valves, and parts manufactured for Section I construction?

Reply: It is the opinion of the Committee that hot isostatically-pressed material UNS K90941 conforming to ASTM A989/A989M-15 may be used in pipe flanges, fittings, valves, and parts manufactured for Section I construction, provided the following requirements are met:

(a) Maximum use temperature shall not exceed that shown in [Table 1](#).

(b) Maximum allowable stress values are shown in [Table 2](#) and [Table 2M](#).

(c) The maximum allowable powder size shall be 0.020 in. (0.5 mm), and the powder shall be produced by the gas atomization process. Immediately following atomization, powders shall remain shielded by an inert gas until it is below a temperature of 105°F (40°C) to ensure that the detrimental absorption of oxygen and the deleterious contaminants is no longer possible. Powder shall be protected during storage by positive nitrogen or argon atmosphere or vacuum to minimize the detrimental pickup of oxygen and other contaminants.

(d) Microstructural examination as listed in para. 4.1.5 of ASTM A989/A989M-15 is mandatory. Sample shall be from the component, stem, protrusion, or test part made

from a single powder blend following the same manufacturing practice.

(e) The chemical composition of a sample from one part from each lot of parts shall be determined by the manufacturer. The composition of the sample shall conform to the chemical requirements prescribed in Table 1 of ASTM A989/A989M-15.

(f) Mechanical test specimens shall be from the component, stem, protrusion, or test part made from a single powder blend following the same manufacturing process.

(g) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. The P-No. assigned for welding these materials shall be the same P-No. as the wrought alloy material specification given in [Table 1](#).

(h) The use of the product standard pressure-temperature ratings (PG-42.1) is not permitted unless this alloy is specifically listed in the applicable standard or Code Case relating to that standard. Parts shall be rated in accordance with the Manufacturer's Standard per PG-11.4.1.

(i) A Manufacturer's Certification shall be furnished to the purchaser stating that material has been manufactured, tested, and inspected in accordance with this Case and that the test results on representative samples meet specification requirements. A report of the test results shall be furnished.

(j) This Case number shall be shown on the Manufacturer's Data Report and identified on the marking and documentation of the material.

**Table 1
Maximum Use Temperature**

ASME Specification (To Be Used for Allowable Stress Values and P-No.)	UNS Number	Grade	P-Number	Group	Temperature, °F (°C)
SA-182/SA-182M	K90941	F9	5B	1	850 (454)

**Table 2
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi, for UNS K90941, Grade F9
100	24.3
200	24.2
300	23.5
400	23.4
500	23.3
600	22.9
650	22.6
700	22.1
750	21.4
800	20.6
850	19.6

**Table 2M
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa, for UNS K90941, Grade F9
40	168
65	167
100	166
150	162
200	161
250	161
300	159
325	157
350	155
375	152
400	147
425	142
450	137
475 [Note (1)]	121

NOTE: (1) This value is provided at 475°C for interpolation use only. The maximum use temperature is 454°C.

Case 2932

Steam Cleaning of High-Pressure Vessels

Section VIII, Division 3

Approval Date: September 17, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may steam cleaning be used on a high-pressure vessel constructed to Section VIII, Division 3?

Reply: It is the opinion of the Committee that steam cleaning may be used, provided the following requirements are met:

(a) The cleaning shall be conducted at ambient pressure with the vessel open to the atmosphere to prevent any pressure buildup.

(b) The cleaning shall be conducted only on surfaces that have combined applied and residual tensile stresses less than 6 ksi (40 MPa) at ambient pressure.

(c) The metal temperature in any portion of the vessel shall not exceed 250°F (121°C) at any time during the cleaning process.

(d) The surfaces contacted by the steam shall be thoroughly dried as soon as practicable after cleaning.

(e) The requirement for steam cleaning shall be provided in the User's Design Specification (UDS).

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2933

Use of Alloy SUS444TB Tubing in Accordance With JIS G 3463:2012 in the Construction of Heating Boilers Per Part HF

Section IV

Approval Date: October 2, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may alloy SUS444TB tube meeting the material requirements of JIS G 3463:2012 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that alloy SUS444TB tube meeting the material requirements of JIS G 3463:2012 may be used in the construction of heating boilers under Section IV, Part HF, provided the following requirements are met:

(a) The allowable stress values for seamless tube with alloy SUS444TB shall be as listed in [Table 1](#) and [Table 1M](#).

(b) The allowable stress values for welded tube shall be those listed in [Table 1](#) and [Table 1M](#) multiplied by a weld joint factor of 0.85.

(c) The minimum tensile strength shall be 59.5 ksi (410 MPa).

(d) The minimum yield strength shall be 35.5 ksi (245 MPa).

(e) For the purpose of welding and brazing procedures and performance qualifications, this material shall be considered P-No. 7, Group 2.

(f) For external pressure, Section II, Part D, Figure CS-2 shall be used.

(g) This material may utilize the minimum thickness exceptions of HF-301.1(c).

(h) Flattening or flaring tests shall be made on all tube including seamless tube.

(i) The tube shall be made by a seamless process, laser welding, electric resistance welding, or by an automatic welding process with no addition of filler metal in the welding operation.

(j) Minimum wall thickness of tube shall not be less than 0.020 in. (0.5 mm), and the outside diameter shall not exceed 0.98 in. (24.9 mm).

(k) The elongation values in [Table 2](#) and [Table 3](#) shall apply to all tube.

(l) Welded tube shall be tested in accordance with the requirements and methods for reverse flattening tests.

(m) The materials Manufacturer or vendor shall submit an inspection certificate (reference JIS G 3463:2012, clauses 12 and 14) to the purchaser with a statement that the tube has been manufactured, inspected, and tested in accordance with the requirements of the JIS Specification and this Case.

(n) The materials Manufacturer or vendor shall identify the material being provided. The identification shall be traceable to the inspection certificate.

(o) All other requirements of Section IV shall be met.

(p) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	11.9
150	11.9
200	11.9
250	11.7
300	11.5
350	11.4
400	11.3
450	11.1
500	11.0

GENERAL NOTE: The maximum thickness of the material covered by this Table is $\frac{3}{8}$ in.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	81.8
65	81.7
100	81.6
125	80.4
150	78.4
175	74.8
200	71.9
225	69.5
250	67.7
275 [Note (1)]	65.9

GENERAL NOTE: The maximum thickness of the material covered by this Table is 9.5 mm.

NOTE: (1) The maximum allowable use temperature is 260°C. The value for 275°C is provided for interpolation only.

Table 2
Minimum Elongation, %, For SUS444TB Tube Based on Outside Diameter

Test Piece Per JIS Z 2241	Minimum Elongation, %, for Outside Diameter, in. (mm)		
	Less Than 0.394 in. (10 mm)	0.394 in. (10 mm) or Over But Less Than 0.787 in. (20 mm)	0.787 in. (20 mm) or Over
No. 11 Tube form test piece	12%	15%	20%
No. 12 Strip form test piece [Note (1)]	...	...	20%

NOTE: (1) See Table 3.

Table 3
Minimum Elongation, %, for Alloy SUS444TB Tube With Less Than 0.315 in. (8 mm) Wall Thickness

Test Piece Per JIS Z 2241	Minimum Elongation, %, for Wall Thickness, in. (mm)								
	0.315 in. (8 mm) and Over	>0.276 in. (7 mm) to <0.315 in. (8 mm)	>0.236 in. (6 mm) to 0.276 in. (7 mm)	>0.197 in. (5 mm) to 0.236 in. (6 mm)	>0.157 in. (4 mm) to 0.197 in. (5 mm)	>0.118 in. (3 mm) to 0.157 in. (4 mm)	>0.078 in. (2 mm) to 0.118 in. (3 mm)	>0.039 in. (1 mm) to 0.078 in. (2 mm)	0.039 in. (1 mm) and Under
No. 12 Parallel to axis	20%	20%	18%	17%	16%	14%	12%	11%	10%

GENERAL NOTE: When the tensile test is carried out using No. 12 test pieces from tubes with wall thickness less than 0.315 in. (8 mm), the minimum elongation values in this Table shall apply.

Case 2934

Use of Alloy SUS444TP Pipe in Accordance With JIS G 3459:2016 in the Construction of Heating Boilers Per Part HF

Section IV

Approval Date: October 2, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may alloy SUS444TP pipe meeting the material requirements of JIS G 3459:2016 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that alloy SUS444TP pipe meeting the material requirements of JIS G 3459:2016 may be used in the construction of heating boilers under Section IV, Part HF, provided the following requirements are met:

(a) The allowable stress values for seamless pipe with alloy SUS444TP shall be as listed in [Tables 1](#) and [1M](#).

(b) The allowable stress values for welded pipe shall be those listed in [Tables 1](#) and [1M](#) multiplied by a weld joint factor of 0.85.

(c) The minimum tensile strength shall be 59.5 ksi (410 MPa).

(d) The minimum yield strength shall be 35.5 ksi (245 MPa).

(e) For the purpose of welding and brazing procedures and performance qualifications, this material shall be considered P-No. 7, Group 2.

(f) For external pressure, Figure CS-2 of Section II, Part D shall be used.

(g) This material may utilize the minimum thickness exceptions of HF-301.1(c).

(h) Flattening tests shall be made on all pipe including seamless pipe.

(i) The elongation values in [Table 2](#) shall apply to all pipe including pipe whose outside diameter is less than 1.574 in. (40 mm).

(j) The pipe shall be made by a seamless process, laser welding, electric resistance welding, or by an automatic welding process with no addition of filler metal in the welding operation.

(k) The materials Manufacturer or vendor shall submit inspection documents (reference JIS G 3459:2016, clauses 15 and 17) to the purchaser with a statement that the pipe has been manufactured, inspected, and tested in accordance with the requirements of the JIS Specification and this Case.

(l) The materials Manufacturer or vendor shall identify the material being provided. The identification shall be traceable to the inspection documents.

(m) All other requirements of Section IV shall be met.

(n) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	11.9
150	11.9
200	11.9
250	11.7
300	11.5
350	11.4
400	11.3
450	11.1
500	11.0

GENERAL NOTE: The maximum thickness of the material covered by this Table is $\frac{3}{8}$ in.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	81.8
65	81.7
100	81.6
125	80.4
150	78.4
175	74.8
200	71.9
225	69.5
250	67.7
275 [Note (1)]	65.9

GENERAL NOTE: The maximum thickness of the material covered by this Table is 9.5 mm.

NOTE: (1) The maximum allowable use temperature is 260°C. The value for 275°C is provided for interpolation only.

Table 2
Minimum Elongation, %, For SUS444TP Pipe

Test Piece Per JIS Z 2241	Minimum Elongation, %, for Wall Thickness, in. (mm)								
	0.315 in. (8 mm) and Over	>0.276 in. (7 mm) to <0.315 in. (8 mm)	>0.236 in. (6 mm) to 0.276 in. (7 mm)	>0.197 in. (5 mm) to 0.236 in. (6 mm)	>0.157 in. (4 mm) to 0.197 in. (5 mm)	>0.118 in. (3 mm) to 0.157 in. (4 mm)	>0.078 in. (2 mm) to 0.118 in. (3 mm)	>0.039 in. (1 mm) to 0.078 in. (2 mm)	0.039 in. (1 mm) and Under
No. 12 Strip form, Parallel to axis	20%	20%	18%	17%	16%	14%	12%	11%	10%
No. 5 Flat form, perpendicular to axis	14%	14%	12%	11%	10%	8%	6%	5%	4%

Case 2936

Use of ASTM A372/A372M-16, Grade J, Class 110 With Addition of 5 ppm to 20 ppm Boron

Section VIII, Division 3

Approval Date: September 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ASTM A372/A372M-16, Grade J, Class 110 with the addition of 5 ppm to 20 ppm boron be used for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that ASTM A372/A372M-16, Grade J, Class 110 with the addition of 5 ppm to 20 ppm boron may be used for Section VIII, Division 3 construction, provided the following requirements are met.

(a) All provisions of ASTM A372/A372M-16, Grade J, Class 110 shall apply except as modified by this Case.

(b) The design temperature shall not exceed 122°F (50°C).

(c) This material shall not be used for welded construction. No welding is permitted on this material.

(d) The steel shall be vacuum degassed before or during the pouring of the ingot or continuous casting, as applicable, in order to remove objectionable gases, particularly hydrogen.

(e) The yield strength values, S_y , shall be those shown in Table Y-1 of Section II, Part D for SA-372 Grade J, Class 110 material.

(f) The tensile strength values, S_u , shall be those shown in Table U of Section II, Part D for SA-372 Grade J, Class 110 material.

(g) Physical properties may be taken from Section II, Part D for Carbon and Low Alloy Steels, Material Group C (1Cr- $\frac{1}{5}$ Mo) or from data obtained by the user as permitted in Section II, Part D, Subpart 2.

(h) This Case number shall be shown on the material marking and documentation, and the Manufacturer's Data Report.

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Case 2937

Allowing Burst Testing to Determine MAWP of HLW Water Heaters and Storage Tanks

Section IV

Approval Date: December 7, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may burst testing be used instead of a proof test as required by HLW-502 in the construction of Section IV, Part HLW water heaters and storage tanks in order to determine their MAWP?

Reply: It is the opinion of the Committee that burst testing may be used instead of a proof test as required by HLW-502 in the construction of Section IV water heaters and storage tanks in order to determine their MAWP, provided the following requirements are met:

(a) This Case shall only be used for pressure parts under internal pressure.

(b) The material of the construction shall be limited to materials allowed to Section IV, Part HLW.

(c) The design pressure of any component part proof tested by this method shall be established by a hydrostatic test to failure by rupture of a full-size sample of such part. As an alternative, the hydrostatic test may be stopped when the test pressure reaches a value that will, by the formula in (d), justify the design pressure.

(d) The design pressure, P , for pressure parts proof tested by this method shall be computed by the following formula:

$$P = \frac{P_b}{4} \times \frac{S}{S_a \text{ or } S_m}$$

where

P_b = bursting test pressure

S = specified minimum tensile strength

S_a = average actual tensile strength of test specimens (as required by HG-501.6)

S_m = maximum tensile strength of range of specification

(e) The test shall be witnessed by the Manufacturer's personnel designated to be responsible for the examination, and recorded on the proof test report described in the Quality Control Manual accepted by an Authorized Inspector.

(f) The test shall be witnessed and accepted by an Authorized Inspector.

(g) The part proof tested under the burst test provisions shall not be Code stamped.

(h) This Case does not address all possible safety considerations associated with its use. Safety of testing personnel should be given serious consideration when conducting proof tests, and particular care should be taken during bursting tests. It is the responsibility of the user of this Case to establish appropriate safety and health practices prior to its use.

(i) The Manufacturer's Data Report shall indicate under the Remarks section, the type of proof test, proof test pressure, and acceptance date by the Authorized Inspector.

(j) All other requirements of Section IV, Part HLW shall be met.

(k) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2938-2

Hydrogen Crack Growth Rate Constants, Threshold Stress Intensity Factor K_{IH} , and Critical Crack Size Requirements for SA-372 and SA-723 Steels

Section VIII, Division 3

Approval Date: April 16, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternatives are there in lieu of the following requirements for SA-372 and SA-723 steels for ASME Section VIII, Division 3 pressure vessel construction for hydrogen environments?

- (a) Testing for fatigue crack growth rates in a hydrogen environment in accordance with KD-1023
- (b) Testing for K_{IH} in accordance with KD-1022
- (c) Critical crack size requirement in KD-1010
- (d) Calculation of crack growth rates in KD-430(a)

Reply: It is the opinion of the Committee that the rules of this Case may be used for SA-372 and SA-723 steels for hydrogen environments in lieu of (a) through (d) in the Inquiry.

(a) The crack growth rate at the deepest point on the crack periphery da/dN , in./cycle (m/cycle), shall be a function of the range of stress intensity factor, ΔK , ksi-in.^{1/2} (MPa-m^{1/2}), and the stress intensity factor ratio R_k .

$$da/dN = C[f(R_k)] [g(P)](\Delta K)^m \quad (1)$$

$$\Delta K = K_{I \max} - K_{I \min} \quad (2)$$

$$R_k = K_{I \min}/K_{I \max} \quad (3)$$

where

$f(R_k)$ = function of stress intensity factor ratio, R_k

$g(P)$ = function of hydrogen partial pressure

P = hydrogen partial pressure, psi (MPa)

$K_{I \min}$ = stress intensity factor at minimum load

$K_{I \max}$ = stress intensity factor at maximum load

m = crack growth rate exponent

C in eq. (1) and eq. (5) shall be determined using eq. (4), as follows:

$$C = C_0 \left(\frac{E_0}{E} \right)^m \quad (4)$$

where

C_0 = room temperature crack growth rate factor

E = elastic modulus at operating temperature

E_0 = elastic modulus at room temperature

Factors $f(R_k)$, $g(P)$, C_0 , and m are found in Tables 1 and 1M.

(b) When $\Delta K < \Delta K_0$, where ΔK_0 is defined in Tables 2 and 2M, the calculated fatigue crack growth rate in hydrogen is lower than the fatigue crack growth rate in air, the fatigue crack growth rate factors (C_0 and m) in Tables KD-430/KD-430M and Table D-500 shall be used. Hydrogen partial pressure correction $g(P)$ shall be set to 1.

(c) The following equation shall be used for crack growth rate near the surface.

$$dl/dN = 2C[f(R_k)] [g(P)](\Delta K)^m \quad (5)$$

(d) For $K_{I \min} \leq 0$, the value of $K_{I \min}$ shall be set to 0 in all equations.

(e) The operating pressure shall not exceed 15,000 psi (103 MPa).

(f) The maximum measured tensile strength shall not exceed 133 ksi (915 MPa).

(g) $K_{I \max}$ shall not exceed 36 ksi-in.^{1/2} (40 MPa-m^{1/2}). This value may be used as K_{IH} for fracture mechanics analysis in KD-1010.

(h) The fatigue crack growth rate data provided in this Case are not applicable for welded construction.

(i) This Case number shall be listed in the Manufacturer's Design Report and Manufacturer's Data Report.

Table 1
Room-Temperature Crack Growth Rate Factors

<i>da/dN</i> Values	Factors applicable for ΔK	C_0 , in./cycle	m	$f(R_K)$	$g(P, \text{psi})$
da/dN_{air}	$\Delta K < K_a$	See Table KD-430	See Table KD-430	See Table D-500	Not applicable, use $g(P) = 1$
da/dN_{low}	$\Delta K_a \leq \Delta K < \Delta K_c$	2.54 E-12	6.5	$\frac{1 + 0.43R_K}{1 - R_K}$	For $P < 3,000$ psi, $0.0056P^{0.51}$ For $P > 3,000$ psi, $0.19 + (5.26 \text{ E } -5)P$
da/dN_{high}	$\Delta K \geq \Delta K_c$	8.34 E-10	3.66	$\frac{1 + 2.0R_K}{1 - R_K}$	1.0

GENERAL NOTE: Stress intensity factor limit values ΔK_a and ΔK_c are defined in Table 2.

Table 1M
Room-Temperature Crack Growth Rate Factors

<i>da/dN</i> Values	Factors applicable for ΔK	C_0 , m/cycle	m	$f(R_K)$	$g(P, \text{MPa})$
da/dN_{air}	$\Delta K < K_a$	See Table KD-430M	See Table KD-430M	See Table D-500	Not applicable, use $g(P) = 1$
da/dN_{low}	$\Delta K_a \leq \Delta K < \Delta K_c$	3.5 E-14	6.5	$\frac{1 + 0.43R_K}{1 - R_K}$	For $P < 20.7$ MPa $0.071P^{0.51}$ For $P > 20.7$ MPa, $0.19 + 0.00763P$
da/dN_{high}	$\Delta K \geq \Delta K_c$	1.5 E-11	3.66	$\frac{1 + 2.0R_K}{1 - R_K}$	1.0

GENERAL NOTE: Stress intensity factor limit values ΔK_a and ΔK_c are defined in Table 2M.

Table 2
Stress Intensity Factor Limit Values

Values for P , psi	ΔK_a , ksi-in. ^{0.5}		ΔK_c , ksi-in. ^{0.5}
	Carbon and Low Alloy Steel, $S_Y \leq 90$ ksi	High Strength Low Alloy Steel, $S_Y > 90$ ksi	
$P \leq 3,000$	$1.92(8.6 - 3.0R_k + 7.9R_k^2 - 9.4R_k^3)P^{-0.15}$	$2.02(9.6 + 2.7R_k + 0R_k^2 - 7.8R_k^3)P^{-0.16}$	$2.23(21.66 + 10R_k - 3.7R_k^2)P^{-0.18}$
$P > 3,000$	$2.59(10.6 - 3.7R_k + 9.8R_k^2 - 11.7R_k^3)P^{-0.21}$	$2.72(11.9 + 3.4R_k + 0R_k^2 - 9.6R_k^3)P^{-0.22}$	$3.16(27.4 + 12.7R_k - 4.8R_k^2)P^{-0.25}$

Table 2M
Stress Intensity Factor Limit Values

Values for P , MPa	ΔK_a , MPa-m ^{0.5}		ΔK_c , MPa-m ^{0.5}
	Carbon and Low Alloy Steel, $S_Y \leq 620$ MPa	High Strength Low Alloy Steel, $S_Y > 620$ MPa	
$P \leq 20.7$	$(8.6 - 3.0R_k + 7.9R_k^2 - 9.4R_k^3)P^{-0.15}$	$(9.6 + 2.7R_k + 0R_k^2 - 7.8R_k^3)P^{-0.16}$	$(21.66 + 10R_k - 3.7R_k^2)P^{-0.18}$
$P > 20.7$	$(10.6 - 3.7R_k + 9.8R_k^2 - 11.7R_k^3)P^{-0.21}$	$(11.9 + 3.4R_k + 0R_k^2 - 9.6R_k^3)P^{-0.22}$	$(27.4 + 12.7R_k - 4.8R_k^2)P^{-0.25}$

Case 2939

Use of ASTM A372/A372M-16, Grade N, Classes 100 and 120 and Grade P, Classes 100 and 120 for Class 2 Vessels

Section VIII, Division 2

Approval Date: December 17, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may alloy steels Grade N and Grade P, Classes 100 and 120 conforming to specification ASTM A372/A372M-16 be used for construction of Section VIII, Division 2, Class 2 vessels?

Reply: It is the opinion of the Committee that ASTM A372/A372M-16, Grade N and Grade P, Classes 100 and 120 may be used for Section VIII, Division 2, Class 2 vessels, provided the following requirements are met:

(a) The design temperature shall not exceed 650°F (343°C).

(b) These materials shall not be used for welded construction. No welding is permitted on these materials.

(c) The steel shall be vacuum degassed before or during the pouring of the ingot or continuous casting as applicable, in order to remove objectionable gases, particularly hydrogen.

(d) The yield strength values, S_y , shall be those shown in Table 1 or Table 1M.

(e) The tensile strength values, S_u , shall be those shown in Table 2 or Table 2M.

(f) The allowable stress values shall be those shown in Table 3 or Table 3M.

(g) Physical properties are found in Section II, Part D, as follows:

(1) Thermal Expansion: Table TE-1, Material Group 1

(2) Thermal Conductivity: Table TCD, Material Group D

(3) Modulus of Elasticity: Table TM-1, Material Group B

(h) Applicable requirements for quenched and tempered materials listed in Section VIII, Division 2, Table 3-A.2 shall be met.

(i) The design fatigue curve given in Section VIII, Division 2, Table 3-F.2 or 3-F.2M shall be followed.

(j) Toughness requirements shall be in accordance with Section VIII, Division 2, para. 6.7.3(a).

(k) Requirements given in Section VIII, Division 2, para. 6.7.6.3 shall be met.

(l) Ultrasonic examination shall be made in accordance with Section VIII, Division 2, para. 7.4.10.1(a).

(m) This Case number shall be shown on the material marking and documentation, and the Manufacturer's Data Report.

Table 1
Values of Yield Strength, S_y

Specification No., Grade, Class	Yield Strength, S_y , ksi, for Metal Temperature Not Exceeding, °F								
	100	150	200	250	300	400	500	600	650
ASTM A372/A372M, Grade N, Class 100	100.0	97.5	96.0	94.6	93.5	91.9	90.6	88.9	87.6
ASTM A372/A372M, Grade P, Class 100	100.0	97.5	96.0	94.6	93.5	91.9	90.6	88.9	87.6
ASTM A372/A372M, Grade N, Class 120	120.0	117.0	115.2	113.6	112.2	110.3	108.8	106.7	105.2
ASTM A372/A372M, Grade P, Class 120	120.0	117.0	115.2	113.6	112.2	110.3	108.8	106.7	105.2

Table 1M
Values of Yield Strength, S_y

Specification No., Grade, Class	Yield Strength, S_y , MPa, for Metal Temperature Not Exceeding, °C												
	40	65	100	125	150	175	200	225	250	275	300	325	350 [Note (1)]
ASTM A372/A372M, Grade N, Class 100	689	673	660	651	644	639	634	630	626	622	617	610	601
ASTM A372/A372M, Grade P, Class 100	689	673	660	651	644	639	634	630	626	622	617	610	601
ASTM A372/A372M, Grade N, Class 120	827	807	792	782	773	767	761	757	752	747	740	733	722
ASTM A372/A372M, Grade P, Class 120	827	807	792	782	773	767	761	757	752	747	740	733	722

NOTE: (1) The maximum design temperature for these materials is 343°C. Values above 343°C are provided only for the purpose of interpolation.

Table 2
Values of Tensile Strength, S_u

Specification No., Grade, Class	Tensile Strength, S_u , ksi, for Metal Temperature Not Exceeding, °F							
	100	200	300	400	500	600	650	
ASTM A372/A372M, Grade N, Class 100	115	115	115	115	115	115	113.2	
ASTM A372/A372M, Grade P, Class 100	115	115	115	115	115	115	113.2	
ASTM A372/A372M, Grade N, Class 120	135	135	135	135	135	135	132.9	
ASTM A372/A372M, Grade P, Class 120	135	135	135	135	135	135	132.9	

Table 2M
Values of Tensile Strength, S_u

Specification No., Grade, Class	Tensile Strength, S_u , MPa, for Metal Temperature Not Exceeding, °C							
	40	100	150	200	250	300	325	350 [Note (1)]
ASTM A372/A372M, Grade N, Class 100	793	793	793	793	793	793	790	776
ASTM A372/A372M, Grade P, Class 100	793	793	793	793	793	793	790	776
ASTM A372/A372M, Grade N, Class 120	931	931	931	931	931	931	928	911
ASTM A372/A372M, Grade P, Class 120	931	931	931	931	931	931	928	911

NOTE: (1) The maximum design temperature for these materials is 343°C. Values above 343°C are provided only for the purpose of interpolation.

Table 3
Values of Allowable Stress for Section VIII, Division 2

Specification No., Grade, Class	Allowable Stress, ksi, for Metal Temperature Not Exceeding, °F						
	100	200	300	400	500	600	650
ASTM A372/A372M, Grade N, Class 100	47.9	47.9	47.9	47.9	47.9	47.9	47.9
ASTM A372/A372M, Grade P, Class 100	47.9	47.9	47.9	47.9	47.9	47.9	47.9
ASTM A372/A372M, Grade N, Class 120	56.3	56.3	56.3	56.3	56.3	56.3	56.3
ASTM A372/A372M, Grade P, Class 120	56.3	56.3	56.3	56.3	56.3	56.3	56.3

Table 3M
Values of Allowable Stress for Section VIII, Division 2

Specification No., Grade, Class	Allowable Stress, MPa, for Metal Temperature Not Exceeding, °C									
	40	65	100	125	150	200	250	300	325	350 [Note (1)]
ASTM A372, Grade N, Class 100	330	330	330	330	330	330	330	330	330	330
ASTM A372, Grade P, Class 100	330	330	330	330	330	330	330	330	330	330
ASTM A372, Grade N, Class 120	388	388	388	388	388	388	388	388	388	388
ASTM A372, Grade P, Class 120	388	388	388	388	388	388	388	388	388	388

NOTE: (1) The maximum design temperature for these materials is 343°C. Values above 343°C are provided only for the purpose of interpolation.

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Case 2941

Exemption From Repeated Mechanical Testing as per UCS-85(c) and (i)

Section VIII, Division 1

Approval Date: December 17, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may test results of mechanical testing for nonwelded plates of P-No. 1, Group 1 material, tested in the normalized condition, be accepted when such plates have been used in fabrication of pressure vessels including cold forming and subsequently normalizing, or hot forming at or near the normalizing temperature and cooled in still air, with or without subsequent normalizing, even if the 80% time at temperature for the test specimen requirement of UCS-85(c) has not been met?

Reply: It is the opinion of the Committee that test results of mechanical testing for nonwelded plates of P-No. 1, Group 1 material, tested in the normalized condition, may be accepted when such plates have been used in fabrication of pressure vessels including cold forming and subsequently normalizing, or hot forming at or near the normalizing temperature and cooled in still air,

with or without subsequent normalizing, even if the 80% time at temperature for the test specimen requirement of UCS-85(c) has not been met, provided the following requirements are met:

(a) The plate shall be P-No. 1, Group 1 material at a thickness before forming not exceeding $1\frac{1}{2}$ in. (38 mm).

(b) Any heat treatment or hot forming shall be performed at a temperature above the upper transformation temperature that shall be nominally the same as the plate normalizing temperature range; the tolerance of the normalizing temperature shall not exceed $\pm 20^{\circ}\text{F}$ ($\pm 11^{\circ}\text{C}$) beyond the temperature range indicated on the Material Test Report.

(c) The manufacturer of the formed part shall document, at a minimum, the heat treatment or hot forming temperatures, holding times, and the type of cooling. This information shall accompany the Material Test Report of the plate used.

(d) This Case number shall appear in the part manufacturer's certification.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2942

Full-Strength and Partial-Strength Inset Tube-to-Tubesheet Welds

Section VIII, Division 1; Section VIII, Division 2

Approval Date: December 18, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may inset tube-to-tubesheet welds be used for Section VIII, Divisions 1 and Division 2 construction for full-strength or partial-strength welds in lieu of Section VIII, Division 1, UW-20 and Appendix A; and Section VIII, Division 2, 4.15.10 and Annex 4-C, as applicable?

Reply: It is the opinion of the Committee that in lieu of Section VIII, Division 1, UW-20 and Appendix A; and Section VIII, Division 2, 4.15.10 or and Annex 4-C, as applicable, it is permissible to use alternative rules described herein for inset tube-to-tubesheet welds for full-strength or partial-strength welds, provided that the following requirements are met:

1 INSET WELD CONFIGURATION

(a) Weld detail is shown in Figure 1 as a guideline. A different configuration can be used provided that the macro sections are free of fusion defects and the correct weld size can be verified.

(b) The weld shall be dimensioned in such way to contain the design stress ellipse (dashed line in the right side of Figure 1) whose axes are respectively $2a_{r1}$ and $2a_{r2}$.

(c) Weld dimensional check shall be done in the PQR production mock up macro section [ref. QW-193] (see 5 below) considering the inscribed stress ellipse (dash-dot line in the right side of the sketch, axis $2a_1$ and $2a_2$) in the weld profile. For weld acceptance, the design ellipse must be completely contained in the weld ellipse.

(d) Ellipses centers are located at weld root corner.

(e) The weld profile shall cover the entire end of the tube.

2 MINIMUM WELD LEGS CALCULATION FORMULAS (SEE FIGURE 2)

(a) Calculation of minimum weld leg a_{r1} (tensile stress leg)

$$a_{r1} = \frac{d_0}{2} - \sqrt{\frac{d_0^2}{4} - t \left(d_0 - t \right) \frac{f_w f_d}{E}} \quad (1)$$

(b) Calculation of minimum weld leg a_{r2} (shear stress leg)

$$a_{r2} = \sqrt{2} \frac{[(d_0 - t) t f_d f_w]}{d_0 E} \quad (2)$$

(c) Nomenclature

a_1 = actual tensile stress weld leg dimension (axis of the maximum ellipse inscribed in the weld) ($a_1 \leq t$)

a_2 = actual shear stress weld leg dimension (axis of the maximum ellipse inscribed in the weld) ($a_2 \leq d_g$)

a_{r1} = calculated tensile stress minimum weld leg dimension

a_{r2} = calculated shear stress minimum weld leg dimension

d_g = groove depth

d_o = tube outside diameter

E = weld efficiency

F_d = design strength, not greater than F_t

f_d = ratio of the design strength to the tube strength = F_d/F_t , but not greater than 1.0

f_e = effective weld strength ratio = F_w / F_t ; full-strength welds have $f_e = 1.0$, otherwise, it is a partial-strength weld

F_t = axial tube strength = $\pi t (d_o - t) S_a$

F_w = weld strength = the lesser of F_{wt} , F_{wv} , or F_t

f_w = weld strength factor = S_a / S_w

F_{wt} = weld tension strength = $\pi a_1 (d_o - a_1) S_w E$

F_{wv} = weld shear strength = $\pi d_o a_2 S_w E \frac{\sqrt{2}}{2}$

L_{max} = maximum allowable axial load in either direction on the tube-to-tubesheet joint

S = allowable stress value as given in the applicable part of Section II, Part D

S_a = allowable stress in tube (see S)

S_t = allowable stress of the material to which the tube is welded (see S and UW-20.7 for clad tube-sheets)

S_w = allowable stress in weld (lesser of S_a or S_t)

t = nominal tube thickness

3 MINIMUM REQUIREMENTS

(a) Design ellipsis shall be contained in weld ellipsis.

(b) a_1 shall not be less than a_{r1} .

(c) a_2 shall not be less than a_{r2} .

4 CALCULATION OF MAXIMUM ALLOWABLE AXIAL LOAD

(a) for pressure induced loads

$$L_{\max} = F_w$$

(b) for thermal or thermal plus pressure

(1) for minimum throat (a_1 or a_2) less than t ,

$$L_{\max} = F_w$$

(2) otherwise, $L_{\max} = 2F_w$

5 QUALITY CONTROL

(a) *Weld Procedure Qualification*

All weld procedures used in this Code Case shall be qualified per Section IX, QW-193 and QW-288.

Additionally, when weld efficiencies E greater than 0.70 are used, a three-specimen pull out test using $E = 0.85$ and a nine-specimen pull out test using $E = 1.0$ is required for each PQR specified. The joint efficiency result f_r achieved in the test shall be equal to or greater than the ratio of the design strength to the tube strength f_d . The value of L_{test} as defined below shall be recorded for each test. The value of f_r is the minimum value of L_{test} for all tests divided by the quantity $(A_t S_t)$.

$$f_r = \frac{\min(L_{\text{test } 1}, L_{\text{test } 2}, \dots, L_{\text{test } n})}{A_t S_t}$$

where

A_t = test tube cross sectional area

$L_{\text{test } 1 \dots n}$ = axial load of each test specimen at which failure of the test specimen occurred

S_t = tube material minimum tensile strength

Further mechanical tests on production mock-up are not required when producing tube-to-tubesheet welds within the QW-288 essential variables limits adopted in the PQR.

(b) *Qualification of Welding Operators and Welders*

Welding operators and welders shall be qualified in compliance with Section IX, QW-193.2.

6 PRODUCTION CONTROL

Production NDE and inspections shall be considered as function of the adopted weld efficiency E , as shown in [Table 1](#).

7 DOCUMENTATION

This Case number shall be recorded on the Manufacturer's Data Report.

Figure 1
Inset Weld Preparation and Configuration

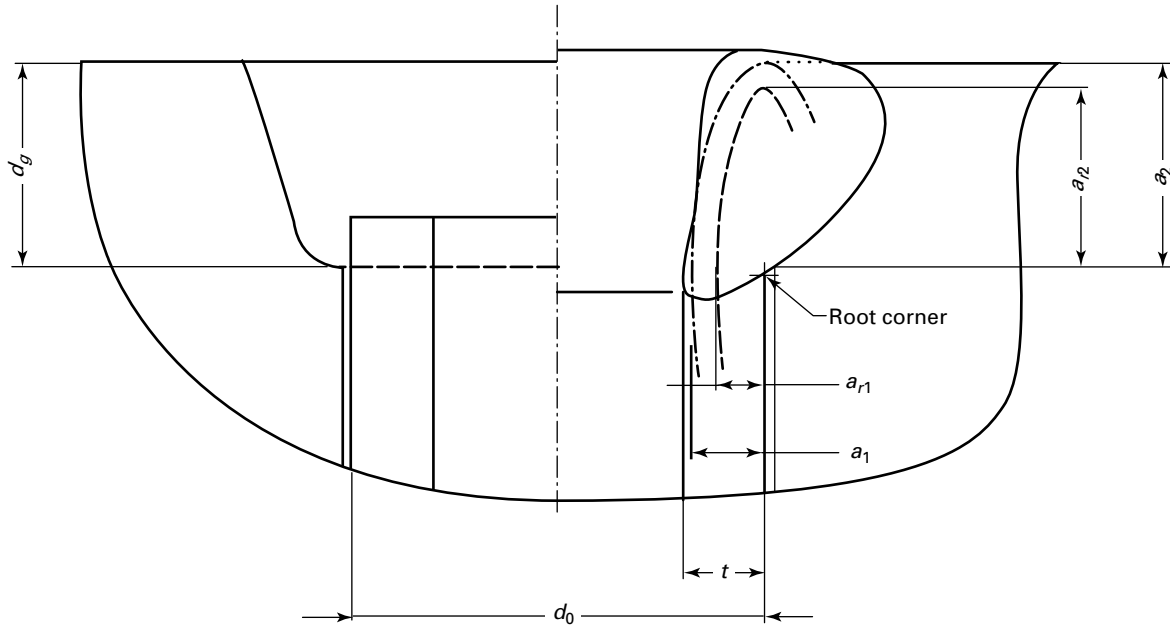


Figure 2
Weld Leg

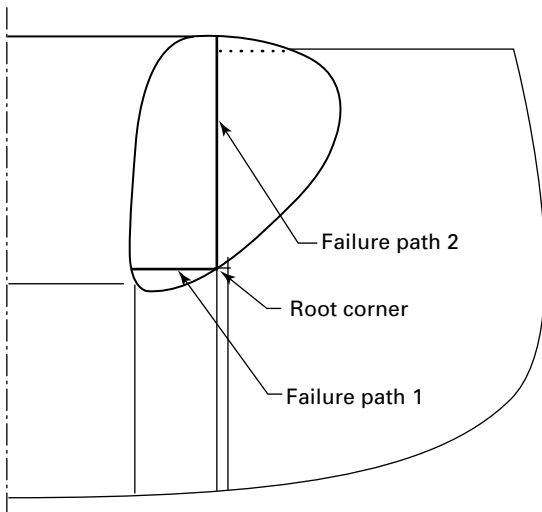


Table 1
Production NDE and Inspections

Adopted Weld Efficiency, <i>E</i>	Production NDE — Inspections
0.70	100% visual examination
0.85	100 % visual examination + 100% PT
1.00	100 % visual examination + 100% PT + production coupon [Note (1)], [Note (2)]

GENERAL NOTES:

- (a) Visual examination shall include fit-up check before welding and completed weld. It shall be performed following the QW-193.1.1 acceptance criteria.
- (b) Liquid penetrant examination (PT) shall meet the requirements of Section V, Article 6, and the acceptance criteria per QW-195.2.

NOTES:

- (1) One production coupon, each comprising 1000 production welds, manufactured by the same welder/welding operator with the same WPS, under the same conditions. This production coupon shall be manufactured following the rules of QW-193.1. Each production coupon (specimen) shall be examined in compliance with QW-193.1.3. In case of geometrical constrictions during production, the same constrictions shall be simulated during the production coupon(s) welding.
- (2) If feasible for geometrical access, any nondestructive volumetric examination suitable to check the weld penetration and soundness can be adopted as alternative to the weld production coupons. In this case at least 2% of the welds manufactured by the same welder/welding operator by the same WPS shall be inspected, randomly selected.

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Case 2943

Time-Dependent Allowable Stresses for Class 1 Vessel Materials Listed in Table 2A or Table 2B of Section II, Part D

Section VIII, Division 2

Approval Date: December 30, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Since Section II, Part D, Table 2A and Table 2B do not provide allowable stress values for design temperatures in the time-dependent regime, what allowable stress values shall be applied when designing Section VIII, Division 2, Class 1 vessels in the time-dependent regime per Section VIII, Division 2, Part 4, para. 4.1.1.3?

Reply: It is the opinion of the Committee that when designing a Section VIII, Division 2, Class 1 vessel per para. 4.1.1.3 in the time-dependent regime, the following additional requirements shall be met:

(a) The allowable stress values at temperatures exceeding those for Section VIII, Division 2, Class 1 in Section II, Part D, Table 2A or Table 2B shall be obtained from Section II, Part D, Table 1A or Table 1B.

(b) The materials permitted shall be those permitted for Section VIII, Division 2, Class 1 in Section II, Part D, Table 2A or Table 2B, and the maximum temperature limit shall be as permitted for Section VIII, Division 1 in Section II, Part D, Table 1A or Table 1B.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2946-1

Use of SA-240/SA-240M Plate Material, UNS S31635, Grades 316Ti and 439, UNS S43932 and UNS S43940, With Minimum Thickness of 0.0394 in. (1.0 mm) After Forming

Section IV

Approval Date: June 8, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-240/SA-240M plate material, UNS S31635, Grades 316Ti and 439, UNS S43932 and UNS S43940 with a minimum thickness of 0.0394 in. (1.0 mm), after forming, be used for the construction of the combustion chamber of Section IV condensing hot water heating boilers?

Reply: It is the opinion of the Committee that the combustion chamber of Section IV condensing hot water heating boilers may be constructed using SA-240/SA-240M, UNS S31635, Grades 316Ti and 439, UNS S43932 and UNS S43940 plate material with a minimum thickness of 0.0394 in. (1.0 mm), after forming, provided the following requirements are met:

(a) The design pressure shall be a maximum of 80 psi (552 kPa).

(b) The design of the heating boiler shall be qualified by proof test for internal pressure according to HG-502.3 and HG-503 for external pressure when there are no design rules in the Code.

(c) The maximum metal temperature shall be limited to 350°F (175°C). The metal temperature shall be determined by computation using accepted heat transfer procedures or by measurements from equipment in service under equivalent operating conditions.

(d) The largest cross-section of the heat exchanger shall be limited to 74 in. (1880 mm).

(e) All other requirements of Section IV shall be met in the construction of boilers or parts thereof.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2947

Depth of Bevel for Tubes Attached by Welding

Section IV

Approval Date: January 7, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: When attaching water heater tubes by welding with a bevel to tubesheets less than $\frac{3}{8}$ in. (10 mm) thick, is it permitted to use a bevel with a depth greater than $\frac{1}{3}$ the tubesheet thickness?

Reply: It is the opinion of the Committee that water heater tubes may be attached by welding, to tubesheets less than $\frac{3}{8}$ in. (10 mm) thick, with a bevel of depth greater than $\frac{1}{3}$ the tubesheet thickness, provided the following requirements are met:

- (a) All other requirements of Section IV shall be met.
- (b) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2949-1

Composite Pressure Vessel Consisting of Inner Steel Layered Shell and Outer Reinforced and Prestressed Concrete Shell for Hydrogen Service for Class 2

Section VIII, Division 2

Approval Date: September 14, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May a composite pressure vessel for hydrogen service consisting of an inner steel layered shell and an outer reinforced and prestressed concrete shell be constructed in accordance with the rules of Section VIII, Division 2, Class 2?

Reply: It is the opinion of the Committee that a composite pressure vessel for hydrogen service consisting of an inner steel layered shell and an outer reinforced and prestressed concrete shell may be constructed in accordance with the rules of Section VIII, Division 2, Class 2, provided the following requirements are met.

1 GENERAL

(a) The maximum design pressure shall be 69 MPa (10,000 psi).

(b) The design temperature is ambient. The maximum ambient temperature and MDMT shall be specified by the user.

(c) An inside austenitic stainless steel liner shall be used in the steel layered shell to act as a barrier for hydrogen penetration. The minimum thickness shall be 6 mm ($\frac{1}{4}$ in.).

(d) Vent holes shall be provided in the steel-layered shell as

(1) a means for the hydrogen that penetrates the liner to escape to the atmosphere

(2) a monitoring system for the integrity of the steel-layered shell to provide a means for venting any hydrogen that permeates the liner and to provide for a monitoring system for any hydrogen that does escape through the liner

(e) A shroud, an example of which is shown in [Figures 1 and 2](#) shall be provided on the outside of the steel-layered shell. The shroud shall have internal grooves as shown in [Figure 3](#). The edges of the shroud near the hemispherical

heads shall be free of weld and shall not be covered by the concrete. The grooves shall be in line with the vent holes to provide means for the hydrogen to escape to the atmosphere.

NOTE: The requirements of Section VIII, Division 3, KD-10 and Section II, Part D, Nonmandatory Appendix A shall be met if any of the pressure-retaining parts are subjected to direct hydrogen contact.

(f) The inner steel vessel shall be designed in accordance with the requirements of Section VIII, Division 2, Part 5. The outer concrete shell shall be designed in accordance with the requirements of ACI 318 (Building Code Requirements for Structural Concrete), ACI 301 (Specifications for Structural Concrete), and ACI 372R (Design and Construction of Circular Wire-and-Strand Wrapped Prestressed Concrete Structures). The stress distribution throughout the steel and concrete shells shall be determined using Lamé's thick-shell equation taking into consideration the deformation compatibility between the steel and concrete shells due to pressure, prestress conditions, and any other applied loads.

(g) The inner steel vessel shall be constructed by a fabricator certified in accordance with Section VIII, Division 2, Class 2. The inner steel-layered vessel shall be inspected by an Authorized Inspector (AI).

(h) The outer reinforced and prestressed concrete shell shall be constructed by a fabricator holding an ASME N-type certificate (Class CC). The outer concrete shell, including reinforcing bars and prestress wires, shall be inspected by an ASME Authorized Inspector (AI) qualified in accordance with Section III, Division 2, Nonmandatory Appendix D2-C, Article D2-C-4000. The inspector shall have a "C" (concrete) endorsement.

(i) The Manufacturer's Data Report of the fabricator responsible for the overall steel/concrete vessel and qualified and certified in accordance with the ASME code shall include all documents pertaining to the inner steel-layered vessel, outer prestressed and reinforced concrete shell, and other pertinent components.

(j) This Case number shall be shown on the vessel nameplate and Data Report.

(k) The supports for the completed vessel shall be attached to the heads.

2 INNER STEEL VESSEL (FIGURES 1 AND 2)

(a) The hemispherical heads and the steel-layered shell of the inner steel vessel shall meet all of the requirements of Section VIII, Division 2, Class 2.

(b) The thickness of the steel-layered shell is based on the longitudinal forces in the shell due to internal pressure. If the allowable stress in the hemispherical heads is the same as the allowable stress of the steel-layered shell, then the thickness of the steel-layered shell will be the same as the thickness of the hemispherical heads. All longitudinal forces in the steel-layered shell due to internal pressure shall be transferred directly to the hemispherical heads.

(c) The wrapping process of the steel-layered shell may result in compressive stress on the inside surface of the steel-layered shell that needs to be considered in the overall stress distribution in the shell. The fabricator shall develop a fabrication procedure for measuring such a stress using strain gages in the inside surface of the shell. At a minimum, strain gages shall be installed at four locations around the circumference of the steel-layered shell midway between the heads. A longitudinal and circumferential strain gage rosette shall be installed at each of the four locations in order to calculate the circumferential stress from the measured strains. This procedure is presently not part of the layered vessel rules in Section VIII, Division 2. The circumferential stress distribution in the various layers due to shrinkage of the longitudinal weld seams shall be calculated based on the measured strain in the strain gages as described in section 4. The results from this procedure may be used in subsequent vessels as a basis for calculating stresses without the need for further strain gage instrumentation.

(d) The prestress wires on the outside of the concrete shell will result in compressive stress on the inside surface of the steel-layered shell that needs to be considered in the overall stress distribution in the steel and concrete shell as described in sections 4 and 5. The fabricator shall develop a fabrication procedure for measuring such a stress. The requirements of Section VIII, Division 3, KF-913 shall be required for the winding procedure of the vessel.

(e) The total tensile stress at any point in the steel-layered shell shall not exceed the limits of equivalent stress given in Section VIII, Division 2, Figure 5.1. Similarly, the compressive stress at any point in the steel-layered shell during operation shall not exceed the allowable compressive stress calculated from Section VIII, Division 2, 4.4.12.

(f) The completed steel-layered shell and welded hemispherical heads of the inner vessel shall be hydrotested to the maximum stress allowed by Section VIII, Division 2 using the thickness of the steel-layered shell as a basis

for calculating test pressure. At this stage the hemispherical heads will not be fully stressed due to this intermediate hydrotest. However, they will be fully stressed when the completed steel/concrete vessel is subjected to the final hydrotest. The intermediate hydrotest shall be witnessed by an Authorized Inspector.

(g) The circumferential weld of layered shell-to-head junction or layered shell-to-layered shell junction shall include a copper chill bar as shown in Figure 4. The space created by the chill bar allows the hydrogen in the weld area to migrate to the layered shell where the vent holes dissipate it to the atmosphere.

3 OUTER CONCRETE SHELL (FIGURES 5 AND 6)

(a) The concrete shell material shall meet the requirements of Section III, Division 2; ACI 301; and ACI 372R.

(b) The prestress wire material shall meet the requirements of ASTM A421 (latest edition) low relaxation wire listed in Section III, Division 2, Table D2-I-1.2. Other wires may be used when specified by the user and are listed in Section III, Division 2. Welding is prohibited on A421 wire during the wire-winding manufacturing process.

(c) The reinforcing bars material shall meet the requirements of ASTM A706 (latest edition) as listed in Section III, Division 2, CC-2310. Other reinforcing bars may be used when specified by the user and are listed in Section III, Division 2.

(d) During the prestressing of the outer concrete shell, the compressive stress on the inside surface of the steel-layered shell shall be measured by strain gages installed on the inside surface of the steel-layered shell. This compressive stress is to be added to the compressive stress obtained during fabrication of the inner steel layered cylinder. The total compressive stress shall be less than the allowable compressive stress of the inner shell liner. Otherwise, adjustments shall be made to the amount of pretension of the prestress wires. The stress distribution in the various layers of the steel-layered shell and the concrete shell due to prestress forces shall be calculated based on the measured strain in the strain gages as described in sections 4 and 5. The results from this procedure may be used in subsequent vessels as a basis for calculating stresses without the need for further strain gage instrumentation.

(e) The total tensile stress at any point in the outer concrete shell shall not exceed the permissible reinforcing bar stress per prestressed concrete provisions of ACI 318. Similarly, the compressive stress at any point in the concrete shall not exceed the permissible limits set in ACI 318 for prestressed concrete structures.

(f) Shear connectors (see Figures 1 and 6) shall be welded to the outside surface of the steel vessel in order to transfer the shear forces between the concrete and steel.

(g) A plastic cover shall be placed over the prestressed wires to protect them from the weather. In addition, a metallic shield shall be placed over the plastic to protect the prestressed wires from any damage during shipping or from atmospheric conditions.

4 GENERAL PRELIMINARY DESIGN PROCEDURE

(a) Design of Inner Steel Vessel

(1) Determine the required thicknesses of the vessel hemispherical heads using the rules of Section VIII, Division 2.

(2) Design the head nozzles and any other attachments in the heads.

(3) Determine the required thickness of the steel-layered shell needed to transfer the longitudinal tensile forces due to internal pressure plus any additional tensile loads on the vessel. This thickness is approximately one-half that required for the full MAWP.

(4) Calculate the MAWP for the steel-layered shell using the thickness determined in (3).

(5) Calculate the required thickness of the support skirt or support saddles required for the vessel using an approximate weight of the reinforced concrete outer shell and prestressed wire. The final required thickness will be checked again subsequent to the final design of the concrete shell.

(b) Design of Outer Concrete Shell

(1) The concrete shell and prestress wires shall resist approximately one-half of the MAWP.

(2) The approximate thickness of the concrete shell and the approximate number of layers of the prestressed wires shall be determined by the following procedure:

(-a) The thickness of the outer concrete shell and the amount of external pressure exerted by the prestress wire are obtained by trial and error [Reference [1]]. Three design criteria must be satisfied in choosing the concrete thickness and amount of external pressure. First, the compressive stress in the concrete due to prestressing and the compressive stress in the steel shell due to prestressing and wrapping must not exceed the allowable compressive stress of the concrete and steel, respectively. Second, the tensile stress in the steel shell due to internal pressure must not exceed the allowable stress and the stress in the concrete must remain in compression. Third, the stress in the steel shell due to hydrostatic testing must remain within the allowable stress and any tension in the concrete shell needs to be resisted by reinforcing bars.

In order to determine the stresses in the steel and concrete, compatibility equations need to be formulated. This is accomplished by defining the radial deflection, δ , of any thick shell due to internal and external pressure as

$$\delta = \left[R^2 (P_i R_i^2 - P_o R_o^2) (1 - 2\mu) + (P_i - P_o) (R_i^2 R_o^2) (1 + \mu) \right] / \left[E R (R_o^2 - R_i^2) \right] \quad (1)$$

When an internal pressure, P_i , is applied at the inside surface of a steel-concrete composite shell, an interface pressure, P_f , is developed at the interface between the outside surface of the steel cylinder and the inside surface of the concrete cylinder. The magnitude of this interface pressure is determined by the following compatibility equation

$$\delta_{sopi} - \delta_{sopf} = \delta_{cipf} - \delta_{cipso} \quad (2)$$

where

δ_{sopi} = deflection of steel cylinder at outside surface due to internal pressure

δ_{sopf} = deflection of steel cylinder at outside surface due to interface pressure

δ_{cipf} = deflection of concrete cylinder at inside surface due to interface pressure

δ_{cipso} = deflection of concrete cylinder at inside surface due to outside pressure

Substituting eq. (1) into eq. (2), rearranging terms, and using the terminology of Figure 7 results in

$$P_f = (P_i K_5 + P_o K_6) / (K_2 + K_3 + K_4) \quad (3)$$

where

$$K_1 = [E_s (R_2^2 - R_1^2)] / [E_c (R_3^2 - R_2^2)]$$

$$K_2 = K_1 [R_2^2 (1 - 2\mu_c) + R_3^2 (1 + \mu_c)]$$

$$K_3 = R_2^2 (1 - 2\mu_c)$$

$$K_4 = R_1^2 (1 + \mu_s)$$

$$K_5 = R_1^2 (2 - \mu_s)$$

$$K_6 = K_1 R_3^2 (2 - \mu_c)$$

Once the value of P_f is obtained from eq. (3), then the circumferential stress in the steel cylinder is obtained from Lamé's equation as [Reference [2]].

$$\sigma_{\theta s} = \left[P_i R_i^2 - P_f R_2^2 + (P_i - P_f) (R_1^2 R_2^2 / R^2) \right] / (R_2^2 - R_1^2) \quad (4)$$

While the circumferential stress in the concrete cylinder is given by

$$\sigma_{\theta c} = \left[P_f R_2^2 - P_o R_3^2 + (P_f - P_o) (R_2^2 R_3^2 / R^2) \right] / (R_3^2 - R_2^2) \quad (5)$$

The above equations are used repeatedly as the thickness of the concrete and values of external pressure are adjusted to meet the design conditions. When the thickness of the concrete and the value external pressure

are found satisfactory, then the number of prestress layers is calculated as shown below.

The external pressure P_o calculated above is provided by the prestress wires. The wires are placed spirally with no space between them. For ease of calculations, an effective thickness is determined by smearing the wire area over 1 in. of shell length. Number of wires per inch = $1.0/d$.

$$t_w = (\pi d^2/4)(1/d) = \pi d/4 \tag{6}$$

The external pressure on the shell provided by a layer of wires is

$$P_o = S_w t_w / R_o \tag{7}$$

where R_o = outside radius of the concrete shell for the first layer of wires, and R_o = outside radius of the concrete shell plus t_w for the second layer of wires, etc.

(-b) The equations for calculating the stress in the concrete and steel inner shell due placing the first layer of prestress wires are given below. When the second layer of prestress wire is placed, a second set of calculations is performed. However, the stress in the steel and concrete shells imposed by the first set of wires is now reduced due to the added second layer, which reduces the tensile stress in the first layer. This reduction has to be accounted for as the process proceeds from one prestress layer to the other. The pertinent equations needed for the analysis are based on eqs. (-a)(1), (-a)(4), and (-a)(5) and the details shown in Figure 8. The derivation of the equations is shown below.

In Figure 8, the outer steel layer shown represents the prestressing wires that are already in place and p_o is the pressure on them from a new additional wire. The two unknowns in the figure are interface pressures P_1 and P_2 . These are obtained from the deflection, δ , compatibility equations

$$\begin{aligned} \delta \text{ of the outer surface of the inner steel shell} &= \\ \delta \text{ of the inner surface of the concrete shell} & \end{aligned} \tag{8}$$

Substituting eq. (-a)(1) into eq. (8), rearranging terms, and using the terminology of Figure 8 results in

$$P_1(C_1 + C_2) - C_3P_2 = C_4 \tag{9}$$

Similarly,

$$\begin{aligned} \delta \text{ of the outer surface of the concrete shell} &= \\ \delta \text{ of the inner surface of the outer steel shell} & \end{aligned} \tag{10}$$

Substituting eq. (-a)(1) into eq. (10), rearranging terms, and using the terminology of Figure 8 gives

$$C_5P_1 - P_2(C_6 + C_7) = C_8 \tag{11}$$

Solving eqs. (9) and (11) for P_1 and P_2 results in

$$P_1 = C_{11}/C_{12} \tag{12}$$

$$P_2 = C_9/C_{10} \tag{13}$$

where

$$\begin{aligned} C_1 &= (E_c/E_s)(R_2^2 - R_1^2)(R_1)[(R_1^2 + R_f^2) - \mu_s(R_1^2 - R_f^2)] \\ C_2 &= (R_1^2 - R_i^2)(R_1)[(R_2^2 + R_1^2) + \mu_c(R_2^2 - R_1^2)] \\ C_3 &= 2(R_1^2 - R_i^2)R_1R_2^2 \\ C_4 &= 2(E_c/E_s)(R_2^2 - R_1^2)p_iR_i^2R_1 \\ C_5 &= 2(R_o^2 - R_2^2)R_1^2R_2 \\ C_6 &= (R_o^2 - R_2^2)(R_2)[(R_2^2 + R_1^2) - \mu_c(R_2^2 - R_1^2)] \\ C_7 &= (E_c/E_s)(R_2^2 - R_1^2)(R_2)[(R_o^2 + R_2^2) + \mu_s(R_o^2 - R_2^2)] \\ C_8 &= -2(E_c/E_s)(R_2^2 - R_1^2)p_oR_2R_o^2 \\ C_9 &= C_8(C_1 + C_2) - C_4C_5 \\ C_{10} &= C_3C_5 - (C_1 + C_2)(C_6 + C_7) \\ C_{11} &= C_4 + (C_3C_9/C_{10}) \\ C_{12} &= C_1 + C_2 \end{aligned}$$

Equations (-a)(4), (-a)(5), (12), and (13) are used to obtain the stress in the inner steel shell, the concrete shell, and the prestress wires.

(-c) Calculate the stress in a steel-concrete shell due to the full MAWP. The stress distribution in the steel-layered shell shall be obtained from Lamé's equation using P_i and P_f . The stress in the concrete shell shall be obtained from Lamé's equation using P_f and P_o . The value of P_o is based on the total number of wire layers.

(-1) Circumferential stress in steel-layered shell

$$\sigma_{\theta s} = \frac{P_i R_i^2 + P_i \left(\frac{R_i^2 R_f^2}{r^2} \right) - P_f R_f^2 - P_f \left(\frac{R_i^2 R_f^2}{r^2} \right)}{R_f^2 - R_i^2} \tag{14}$$

(-2) Circumferential stress in concrete shell

$$\sigma_{\theta c} = \frac{P_f R_f^2 + P_f \left(\frac{R_f^2 R_o^2}{r^2} \right) - P_o R_o^2 - P_o \left(\frac{R_f^2 R_o^2}{r^2} \right)}{R_o^2 - R_f^2} \tag{15}$$

(-d) If the tensile stress in the steel-layered shell or the concrete shell exceeds the allowable, then the thickness of the concrete shell and/or the value of P_o shall be adjusted until the stresses are within the allowable stress.

(-e) Calculate the interface pressure, P_f between the steel and concrete shells due to assumed external pressure, P_o , and letting $P_i = 0$ using the deflection compatibility equation.

$$\begin{aligned} \text{deflection of the outside} & & \text{deflection of inside} \\ \text{surface of the steel-} & = & \text{surface of the concrete shell} \\ \text{layered shell due to } P_f & & \text{due to } P_f \text{ and } P_o \end{aligned} \tag{16}$$

(-f) Calculate the compressive stress in a steel-concrete shell due to P_o . If the compressive stress in the steel-layered shell or the concrete shell exceeds the allowable stress, then the thickness of the concrete

shell and/or the value of P_o shall be adjusted until the compressive stresses are within the allowable stress.

(-g) The thickness, t_c , and pressure, P_o , determined from the steps above will be finalized when a detailed stress distribution analysis is performed.

5 DETAILED STRESS ANALYSIS

The actual stress distribution in the steel and concrete shells is obtained as follows:

(a) Welding of the longitudinal seams of any individual layer in a layered shell causes shrinkage of the welds. This shrinkage results in locked-in residual tensile stress in the individual layer being welded and compressive stress in the layers underneath it. These secondary stresses are normally ignored in commercially fabricated layered vessels since they do not contribute to the stress calculations for determining the required thickness of the layered shell. However, they are important in the steel-concrete composite vessel since they must be combined with the stresses obtained from the prestressing wires on the outside surface of the concrete as well as the stress due to internal pressure in order to obtain the full stress pattern needed for design.

The compressive stress in the inner layer due to weld shrinkage of the longitudinal welds of the outer layers is obtained from strain gage rosettes attached to the inside surface of the inner layer. The pertinent equations for calculating the stress from measured strain are

$$\sigma_\theta = \left[E_s / (1 - \mu_s^2) \right] (\epsilon_\theta + \mu_s \epsilon_L) \quad (17)$$

$$\sigma_L = \left[E_s / (1 - \mu_s^2) \right] (\epsilon_L + \mu_s \epsilon_\theta) \quad (18)$$

(b) The stress distribution in the steel layered shell due to weld shrinkage of the longitudinal welds of the layers can be formulated from deflection compatibility equations and the stress results obtained from eqs. (a)(17) and (a)(18) for the inner layer. The stress pattern through the wall of a layered cylinder due to shrink fitting the layers (autofrettaging) is based on the details shown in Figure 9 as well as the derivations and experimental verifications given by [Reference 3].

Define t_o as the thickness of the outer layer being shrunk and t_i as the thickness of all layers underneath it. Also, define R_o and R_f as the outside and inside radii of the layer being shrunk and R_f and R_i as the outside and inside radii of all layers underneath it as shown in Figure 9. Define w as the width of the weld seam in the outer layer and n as the number of weld seams in the outer layer. Define P_f as the interface pressure between the outer layer and all layers underneath it.

(1) The deflection of the inside surface of a cylinder due to internal and external pressure is given by [Reference 2].

$$\delta_I = \left[R_i P_i (R_o^2 + R_i^2) + \mu_s R_i P_i (R_o^2 - R_i^2) - 2 P_o R_i R_o^2 \right] / E_s (R_o^2 - R_i^2) \quad (19)$$

Similarly, the deflection of the outside surface of a cylinder due to internal and external pressure is given by [Reference 2].

$$\delta_o = \left[2 P_i R_i^2 R_o - R_o P_o (R_o^2 + R_i^2) + \mu_s R_o P_o (R_o^2 - R_i^2) \right] / E_s (R_o^2 - R_i^2) \quad (20)$$

The shrinkage due to welding of seam w in the outer layer is given by

$$\delta_w = (K)(w) \quad (21)$$

The value of the weld shrink factor K in eq. (21) depends on many variables such as weld width and thickness, weld process, and number of weld passes. The value of K is obtained by trial and error as explained below.

The inward radial deflection of the outer layer due to weld shrinkage of seam w is expressed as

$$\Delta_w = (\delta_w n) / (2\pi) \quad (22)$$

The compatibility equation between layer t_o and layer t_i is given by

$$\Delta_w - \Delta_o = \Delta_i \quad (23)$$

From eq. (19), the deflection of the inside surface of outer layer to due to interface pressure P_f is

$$\Delta_i = \left(P_f R_f \right) \left[R_o^2 (1 + \mu_s) + R_f^2 (1 - \mu_s) \right] / E_s (R_o^2 - R_f^2) \quad (24)$$

Similarly, from eq. (19), the deflection of the outside surface of inner layer t_i due to interface pressure P_f is

$$\Delta_o = \left(P_f R_f \right) \left[R_f^2 (-1 + \mu_s) - R_i^2 (1 + \mu_s) \right] / E_s (R_f^2 - R_i^2) \quad (25)$$

Substituting eqs. (21), (22), (24), and (25) into eq. (23), and solving for the unknown interface pressure P_f gives

$$P_f = K_3 / \left[R_f (K_1 - K_2) \right] \quad (26)$$

where

$$\begin{aligned} K_1 &= R_o^2 (1 + \mu_s) + R_f^2 (1 - \mu_s) / [R_o^2 - R_f^2] \\ K_2 &= R_f^2 (-1 + \mu_s) - R_i^2 (1 + \mu_s) / [R_f^2 - R_i^2] \\ K_3 &= (E_s)(K)(w)(n) / 2\pi \end{aligned}$$

(2) The above derivations are based on the following assumptions:

(-a) The width w of the weld seams is the same in all layers.

(-b) Weld parameters such as voltage, amperes, speed, etc., are constant from weld to weld such that the shrinkage constant K does not vary from weld to weld or layer to layer.

(-c) The number of welds n in each layer is constant throughout the layers.

(-d) The modulus of elasticity, E_s , is the same for all layers.

(c) The actual interface pressure P_f in eq. (b)(1)(26) is based on a selected value of constant K . Once the pressure P_f is known then the circumferential stresses in the outer and inner cylinders are obtained from the following equations.

(1) Due to external pressure P_o ,

$$\sigma_{\theta} = \left[\frac{-P_o R_o^2 - P_o (R_i^2 R_o^2 / R^2)}{(R_o^2 - R_i^2)} \right] \quad (27)$$

(2) Due to internal pressure P_i ,

$$\sigma_{\theta} = \left[\frac{P_i R_i^2 + P_i (R_i^2 R_o^2 / R^2)}{(R_o^2 - R_i^2)} \right] \quad (28)$$

(3) The value of K in eq. (b)(1)(26) is determined as follows:

(-a) The values of circumferential compressive stress in the inner layer due to wrapping each of the outer layers as obtained from the strain gage readings and eqs. (a)(17) and (a)(18) are plotted as shown in Figure 10.

(-b) A value of K between 0.05 and 0.50 is assumed.

(-c) Equations (b)(1)(26) through (2)(28) are solved for each welded outer layer and the resultant curve based on an assumed value of K is plotted as shown in Figure 10.

If the curve from the equations does not match the actual data then a new value of K is assumed and the procedure is continued until a satisfactory curve is obtained.

Once the value of K is established, then the stress distribution in the various layers due to the wrapping process is determined from eqs. (b)(1)(26) through (2)(28). Figure 11 shows a typical stress distribution in the layered shell due to wrapping stress.

The wrapping stress in the various layers is added to the stress in these layers due to prestressing the concrete outer shell and stress due to internal pressure to obtain the overall stress pattern in the shell.

(d) The stress distribution in the steel layers and concrete shell due to prestressing the concrete shall be obtained by the same procedure outlined above.

(e) The stress in the steel-layered shell due to internal pressure plus steel layer weld shrinkage plus concrete prestressing plus any concrete shrinkage shall be calcu-

lated from eq. (c)(2)(28). The tensile and compressive stresses shall not exceed the allowable stress, S .

(f) The stress in the concrete shell due to internal pressure plus concrete prestressing shall be calculated from eq. (c)(2)(28). The tensile and compressive stresses shall be within the allowable values specified by ACI 318 for prestressed concrete structures.

(g) Discontinuity Stress Between Head and Steel-Concrete Shell. The discontinuity forces are shown in Figure 12. Total unknown forces are H_1 , H_2 , H_3 , M_1 , M_2 , and P_f . The six equations (two equilibrium and four compatibility) required to solve these six unknown forces are

$$H_1 - H_2 - H_3 = 0 \quad (29)$$

$$M_1 - M_2 = 0 \quad (30)$$

$$\delta_s = \delta_h \quad (31)$$

$$\delta_s = \delta_c \quad (32)$$

$$\theta_s = \theta_h \quad (33)$$

$$\theta_s = \theta_c \quad (34)$$

(1) Head Equations

$$\delta_h = \delta_{hP_i} - \delta_{hH_1} + \delta_{hM_1} \quad (35)$$

$$\theta_h = \theta_{hP_i} + \theta_{hH_1} - \theta_{hM_1} \quad (36)$$

where

$$\begin{aligned} \delta_{hP_i} &= \text{radial deflection of head due to internal pressure } P_i \\ &= P_i R_h^2 (1 - \mu_h) / (2E_h t_h) \end{aligned}$$

$$\begin{aligned} \delta_{hH_1} &= \text{radial deflection of head due to shear force } H_1 \\ &= H_1 R_h (2\lambda) / (E_h t_h) \end{aligned}$$

$$\begin{aligned} \delta_{hM_1} &= \text{radial deflection of head due to bending moment } M_1 \\ &= 2M_1 \lambda^2 / (E_h t_h) \end{aligned}$$

$$\begin{aligned} \theta_{hP_i} &= \text{rotation of head due to internal pressure } P_i \\ &= 0 \end{aligned}$$

$$\begin{aligned} \theta_{hH_1} &= \text{rotation of head due to shear force } H_1 \\ &= 2H_1 \lambda^2 / (E_h t_h) \end{aligned}$$

$$\begin{aligned} \theta_{hM_1} &= \text{rotation of head due to bending moment } M_1 \\ &= 4M_1 \lambda^3 / (E_h R_h t_h) \end{aligned}$$

and where $\lambda = [3(1 - \mu_h^2)(R_h/t_h)^2]^{0.25}$

(2) Steel Shell Equations

$$\delta_s = \delta_{sP_i} - \delta_{sP_f} + \delta_{sH_2} + \delta_{sM_2} \quad (37)$$

$$\theta_s = \theta_{sP_i} - \theta_{sP_f} + \theta_{sH_2} + \theta_{sM_2} \quad (38)$$

where

$$\begin{aligned} \delta_{sPi} &= \text{radial deflection of steel shell due to internal pressure } P_i \\ &= P_i R_s^2 [1 - (\mu_s/2)] / (E_s t_s) \\ \delta_{sPf} &= \text{radial deflection of steel shell due to interface pressure } P_f \\ &= P_f R_s^2 / (E_s t_s) \\ \delta_{sH2} &= \text{radial deflection of steel shell due to shear force } H_2 \\ &= H_2 / (2\beta_s^3 D_s) \\ \delta_{sM2} &= \text{radial deflection of steel shell due to bending moment } M_2 \\ &= M_2 / (2\beta_s^2 D_s) \\ \theta_{sPi} &= \text{rotation of steel shell due to internal pressure } P_i \\ &= 0 \\ \theta_{sPf} &= \text{rotation of steel shell due to external pressure } P_f \\ &= 0 \\ \theta_{sH2} &= \text{rotation of steel shell due to shear force } H_2 \\ &= H_2 / (2\beta_s^2 D_s) \\ \theta_{sM2} &= \text{rotation of steel shell due to bending moment } M_2 \\ &= M_2 / (\beta_s^2 D_s) \end{aligned}$$

and where

$$\beta_s = [3(1 - \mu_s^2) / (R_s t_s)^2]^{0.25}$$

$$D_s = E_s t_s^3 / [12(1 - \mu_s^2)]$$

(3) Concrete Shell Equations

$$\delta_c = \delta_{cPf} - \delta_{cPo} + \delta_{cH3} \quad (39)$$

$$\theta_c = \theta_{sPf} + \theta_{cPo} + \theta_{cH3} \quad (40)$$

where

$$\begin{aligned} \delta_{cPf} &= \text{radial deflection of steel shell due to internal pressure } P_i \\ &= P_f R_c^2 / (E_c t_c) \\ \delta_{cPo} &= \text{radial deflection of steel shell due to interface pressure } P_o \\ &= P_o R_c^2 / (E_c t_c) \\ \delta_{cH3} &= \text{radial deflection of steel shell due to shear force } H_3 \\ &= H_3 / (2\beta_c^3 D_c) \\ \theta_{cPf} &= \text{radial deflection of concrete shell due to interface pressure } P_f \\ &= 0 \\ \theta_{cPo} &= \text{radial deflection of concrete shell due to pre-stress pressure } P_o \\ &= 0 \end{aligned}$$

$$\begin{aligned} \theta_{cH3} &= \text{radial deflection of concrete shell due to shear force } H_3 \\ &= H_3 / (2\beta_c^2 D_c) \end{aligned}$$

and where

$$\beta_c = [3(1 - \mu_c^2) / (R_c t_c)^2]^{0.25}$$

$$D_c = E_c t_c^3 / [12(1 - \mu_c^2)]$$

Substituting eqs. (1)(35) through (40) into eqs. (29) through (34) and rearranging terms results in the following six simultaneous equations, written in matrix form, and can be solved for the unknowns $H_1, H_2, H_3, M_1, M_2,$ and P_f .

$$[K][F] = [C] \quad (41)$$

where

$$[K] = \begin{bmatrix} 1 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & -1 & 0 \\ C_1 & C_2 & 0 & -C_3 & C_4 & -C_5 \\ 0 & C_2 & -C_7 & 0 & C_4 & -C_8 \\ -C_3 & C_4 & 0 & C_{10} & C_{11} & 0 \\ 0 & C_4 & -C_{12} & 0 & C_{11} & 0 \end{bmatrix}$$

$$[F] = \begin{bmatrix} H_1 \\ H_2 \\ H_3 \\ M_1 \\ M_2 \\ P_f \end{bmatrix}$$

$$[C] = \begin{bmatrix} 0 \\ 0 \\ 0 \\ C_6 \\ C_9 \\ 0 \end{bmatrix}$$

and

$$\begin{aligned} C_1 &= 2R_h \lambda / (E_h t_h) \\ C_2 &= 1 / (2\beta_s^3 D_s) \\ C_3 &= 2\lambda^2 (E_h t_h) \\ C_4 &= 1 / (2\beta_s^2 D_s) \\ C_5 &= R_s^2 / (E_s t_s) \\ C_6 &= P_i [R_h^2 (1 - \mu_h) / (2E_h t_h) - R_s (1 - \mu_s/2) / (E_s t_s)] \\ C_7 &= 1 / (2\beta_c^3 D_c) \\ C_8 &= R_s^2 / (E_s t_s + R_c^2 / (E_c t_c)) \\ C_9 &= -P_i [R_s^2 (1 - \mu_s/2) / (E_s t_s)] - P_o R_c^2 / (E_c t_c) \\ C_{10} &= 4\lambda^3 / (E_h R_h t_h) \\ C_{11} &= 1 / (\beta_s D_s) \\ C_{12} &= 1 / (2\beta_c^2 D_c) \end{aligned}$$

(4) Once the unknown forces are calculated from eq. (3)(41), the stresses are then determined from the following equations:

(-a) *Steel Head*

(-1) Longitudinal Stress

$$S_L = P_i R_h / 2t_h + 6M_1 / t_h^2 \quad (42)$$

(-2) Circumferential Stress

$$S_c = \delta_h E_h / R_h + (\mu_h) (6M_1 / t_h^2) \quad (43)$$

(-b) *Layered Steel Shell*

(-1) Longitudinal Stress

$$S_L = P_i R_s / 2t_s + 6M_2 / t_s^2 \quad (44)$$

(-2) Circumferential Stress

$$S_c = \delta_s E_s / R_s + (\mu_s) (6M_2 / t_s^2) \quad (45)$$

(-c) *Concrete Shell*

(-1) Longitudinal Stress

$$S_L = 0 \quad (46)$$

(-2) Circumferential Stress

$$S_c = \delta_c E_c / R_c \quad (47)$$

where

$$\begin{aligned} \delta_h &= (1/E_h t_h) [(0.5)(P_i R_h^2)(1 - \mu_h) - 2H_1 R_h \lambda + 2M_1 \lambda^2] \\ \delta_s &= (P_i R_s^2)(1 - \mu_s/2)/(E_s t_s - (P_f R_s^2)/(E_s t_s) + H_2/(2\beta_s^3 D_s) + M_2/(2\beta_s^2 D_s)) \\ \delta_c &= (P_f R_c^2)/(E_c t_c) - (P_o R_c^2)/(E_c t_c) + H_3/(2\beta_c^3 D_c) \end{aligned}$$

(h) At the design stage, consideration must be given to hydrotesting. During final hydrotesting, excessive tensile stress may occur in the concrete. Such condition will require use of reinforcing bars in the concrete to resist tensile forces in accordance with ACI 318.

(i) Long-range creep relaxation of the concrete shall be taken into account when calculating stresses in the steel-layered shell and outer concrete shell due to prestressing and internal pressure per the prestressed concrete provisions of ACI 318, ACI 209R (Prediction of Creep, Shrinkage, and Temperature Effects in Concrete Structures), and Concrete International Journal, June 1979, "Estimating Prestress Losses" by Zia, Preston, Scott, and Workman, pages 32-38.

(j) Fatigue evaluation shall be considered in the overall analysis of the vessel in accordance with Section VIII, Division 2 and ACI 376 (Code Requirements for Design and

Construction of Concrete Structures for Containment of Refrigerated Liquefied Gases and Commentary).

(k) Low temperature evaluation of various components shall be considered in the overall analysis of the vessel.

6 FINAL HYDROTESTING

The completed vessel shall be hydrotested in accordance with Section VIII, Division 2, 8.2. The final hydrotest shall be witnessed by an Authorized Inspector.

7 NOMENCLATURE

E	= modulus of elasticity
MAWP	= maximum allowable working pressure
MDMT	= minimum design metal temperature
P_f	= interface pressure
P_i	= internal pressure
P_o	= outside pressure
r	= radius at any location
R_f	= interface radius between steel-layered shell and concrete shell
R_i	= inside radius
R_o	= outside radius
S	= allowable stress
t_c	= thickness of concrete
δ_{cPfp_o}	= deflection of concrete shell due to interface pressure, P_f , and outside pressure, P_o
$\delta_{sP_iP_f}$	= deflection of steel shell due to internal pressure, P_i , and interface pressure, P_f
ϵ_L	= strain in the longitudinal direction
ϵ_θ	= strain in the circumferential direction
μ	= Poisson's ratio
σ_L	= longitudinal stress
σ_θ	= circumferential stress at any location
$\sigma_{\theta c}$	= circumferential stress at any location in the concrete shell
$\sigma_{\theta s}$	= circumferential stress at any location in the steel layered shell

8 REFERENCES

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 - [2] M. Jawad, 2018. "Stress in ASME Pressure Vessels, Boilers, and Nuclear Components." Wiley/ASME Press.
 - [3] M. Jawad, 1972. "Wrapping Stress and its Effect on Strength of Concentrically Formed Plywalls." ASME Piping and Pressure Vessel Conference, 72-PVP-7.
- (b) The following is a partial list of various publications referenced in the ACI documents in this Case.
- AASHTO M 182 (2005; R 2009) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ACI 211.1 (1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete

ACI 301 (2010; Errata 2011) Specifications for Structural Concrete

ACI 318 (2011; Errata 1 2011; Errata 2 2012; Errata 3-4 2013) Building Code Requirements for Structural Concrete and Commentary

ACI 347 (2004; Errata 2008; Errata 2012) Guide to Formwork for Concrete

ACI 372R (2013) Guide to Design and Construction of Circular Wire-and-Strand-Wrapped Prestressed Concrete Structures.

ACI/MCP-1 (2013) Manual of Concrete Practice Part 1

ACI/MCP-2 (2013) Manual of Concrete Practice Part 2

ACI/MCP-3 (2013) Manual of Concrete Practice Part 3

ACI/MCP-4 (2013) Manual of Concrete Practice Part 4

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AWWA C301 (2007) Prestressed Concrete Pressure Pipe, Steel-Cylinder Type

AWS D1.4/D1.4M (2011) Structural Welding Code - Reinforcing Steel

ASTM A36/A36M-12, Standard Specification for Carbon Structural Steel

ASTM A563-07a, Standard Specification for Carbon and Alloy Steel Nuts

ASTM A615/A615M-13, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A648-12, Standard Specification for Steel Wire, Hard Drawn for Prestressing Concrete Pipe

ASTM A706/A706M-13, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

ASTM A1032-04(R2010), Standard Test Method for Hydrogen Embrittlement Resistance for Steel Wire Hard Drawn Used for Prestressing Concrete Pipe

ASTM A1044/A1044M-10, Standard Specification for Steel Stud Assemblies for Shear Reinforcement of Concrete

ASTM A1064/A1064M-13, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM C33/C33M-13, Standard Specification for Concrete Aggregates

ASTM C39/C39M-14, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

ASTM C143/C143M-12, Standard Test Method for Slump of Hydraulic-Cement Concrete

ASTM C150/C150M-12, Standard Specification for Portland Cement

ASTM C172/C172M-10, Standard Practice for Sampling Freshly Mixed Concrete

ASTM C192/C192M-13a, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory

ASTM C295/C295M-12, Petrographic Examination of Aggregates for Concrete

ASTM C311/C311M-13, Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete

ASTM C494/C494M-13, Standard Specification for Chemical Admixtures for Concrete

ASTM C618-12a, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

ASTM C881/C881M-10, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

ASTM C1017/C1017M-07, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete

ASTM C1077-13b, Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

ASTM C1218/C1218M-99(R2008), Standard Specification for Water-Soluble Chloride in Mortar and Concrete

ASTM C1260-07, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)

ASTM C1567-13, Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)

ASTM D3350-12, Polyethylene Plastics Pipe and Fittings Materials

ASTM F844-07a(R2013), Washers, Steel, Plain (Flat), Unhardened for General Use

Figure 1
Example of Steel-Layered Vessel

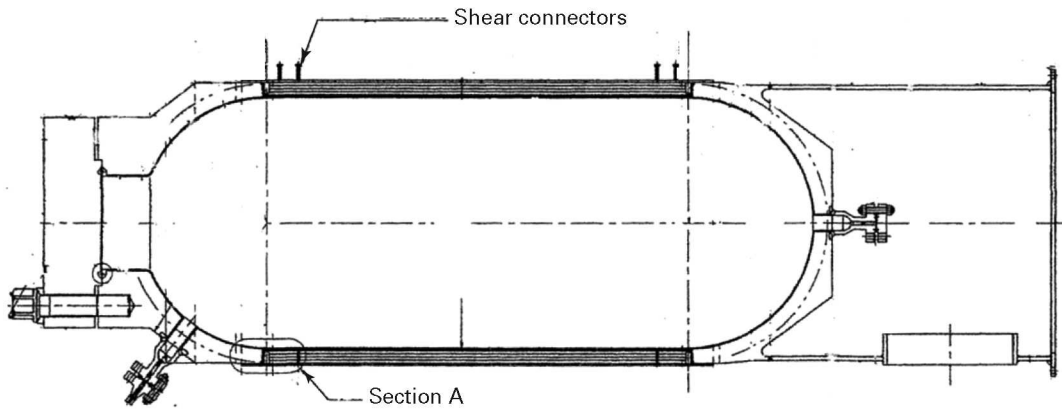
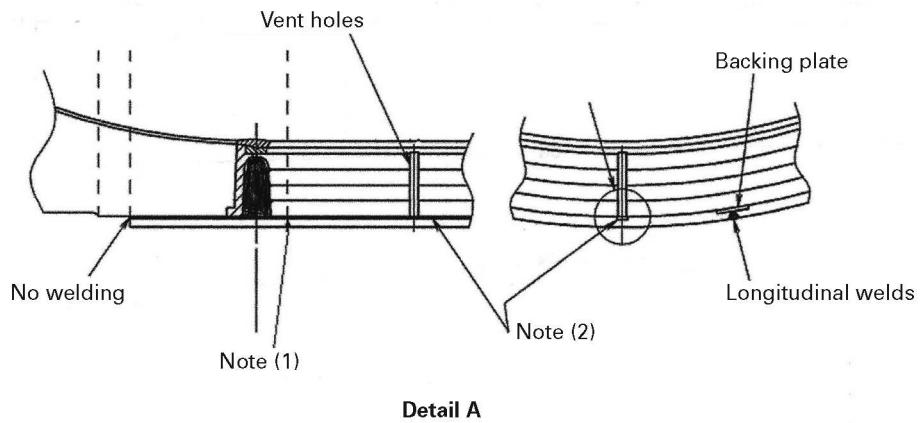


Figure 2
Detail of Head-to-Steel Layered Shell Junction



NOTES:

- (1) This weld shall be made after the hydrostatic test. Do not weld to layer.
- (2) Longitudinal grooves: the orientation of these grooves shall be placed directly above the vent holes.

Figure 3
Shroud for the Vent Holes in the Layered Steel Shell

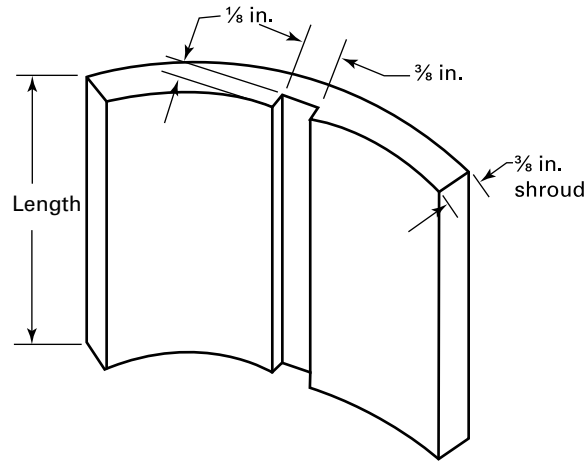


Figure 4
Head-to-Layered Shell Detail

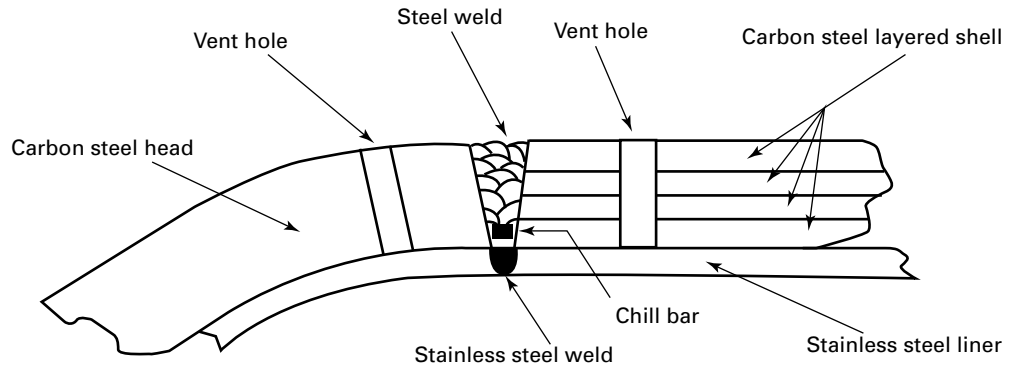


Figure 5
Example of Outer Concrete Shell

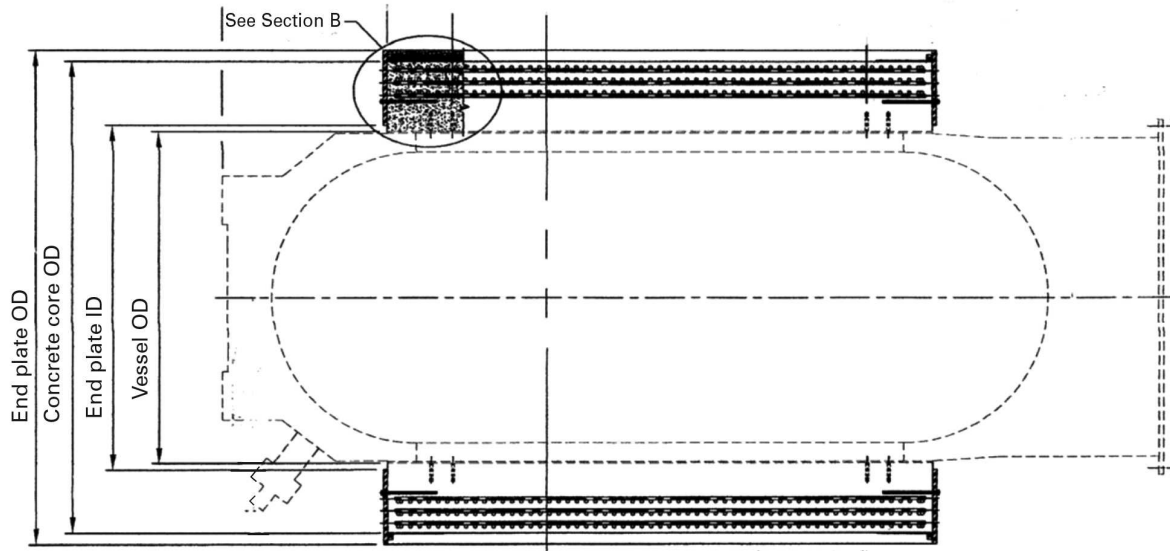


Figure 6
Details of Concrete Reinforcement

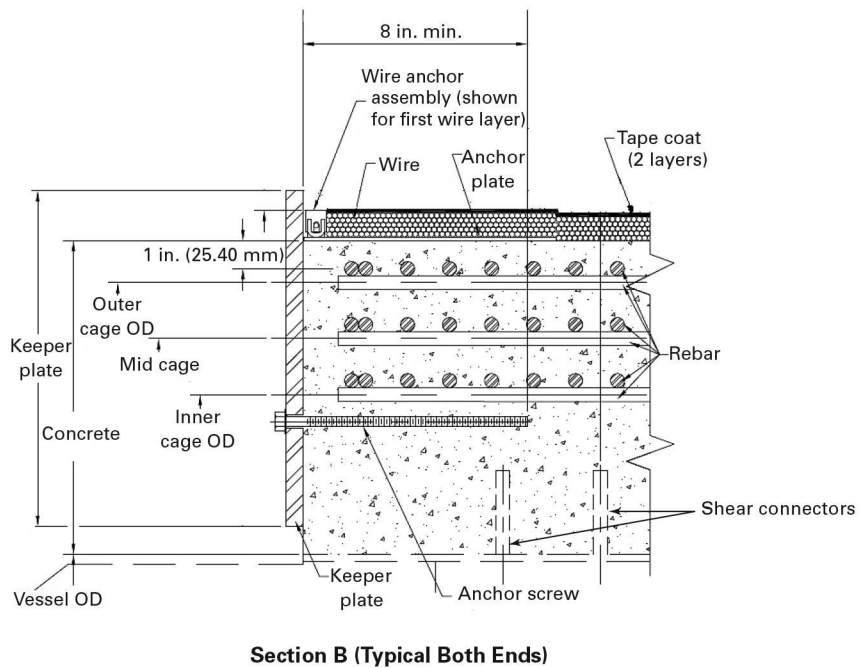


Figure 7
Steel-Concrete Composite Shell

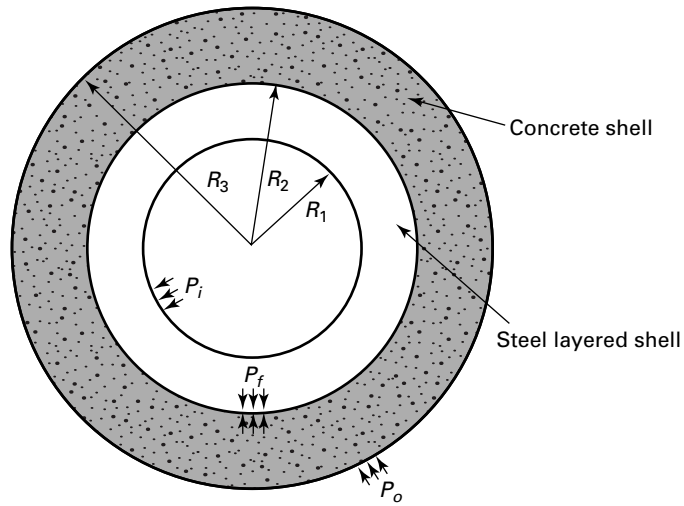


Figure 8
Steel-Concrete-Steel Interaction

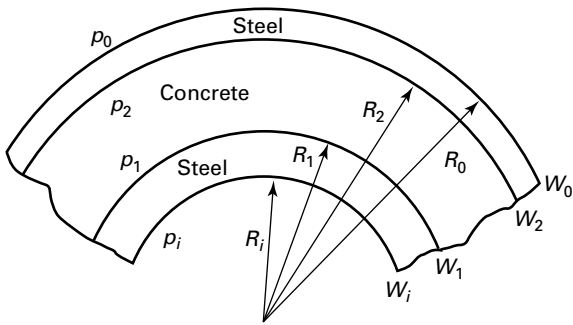


Figure 9
Layered Vessel

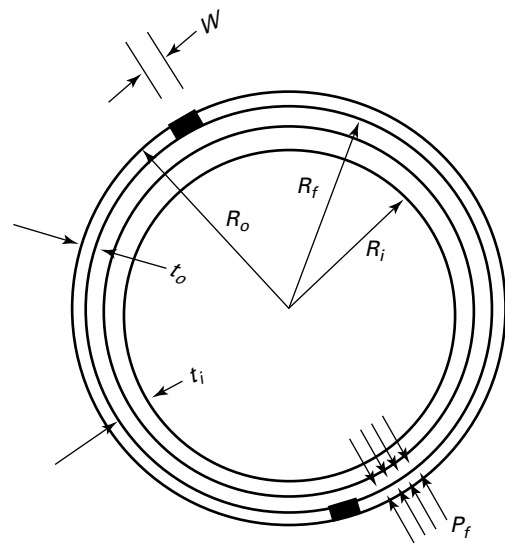


Figure 10
Stress from Strain Gage Measurements Versus Stress from Assumed Value of K

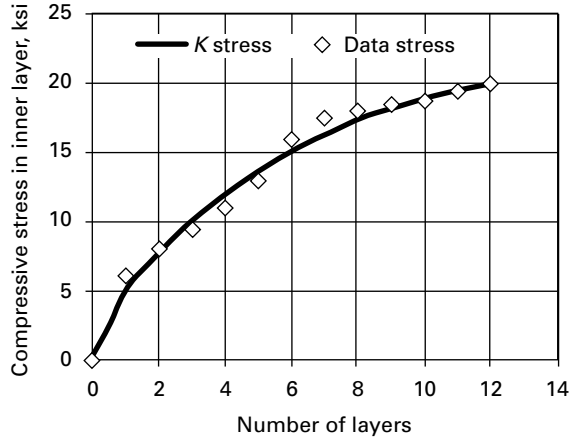


Figure 11
Wrapping Stress Distribution Through Thickness

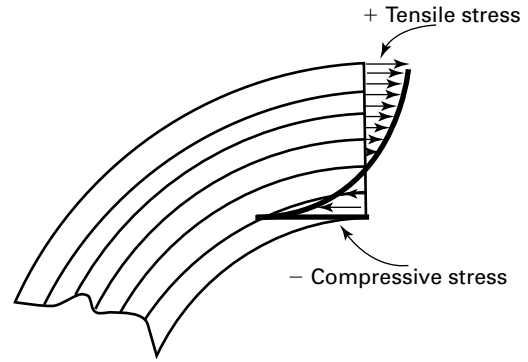
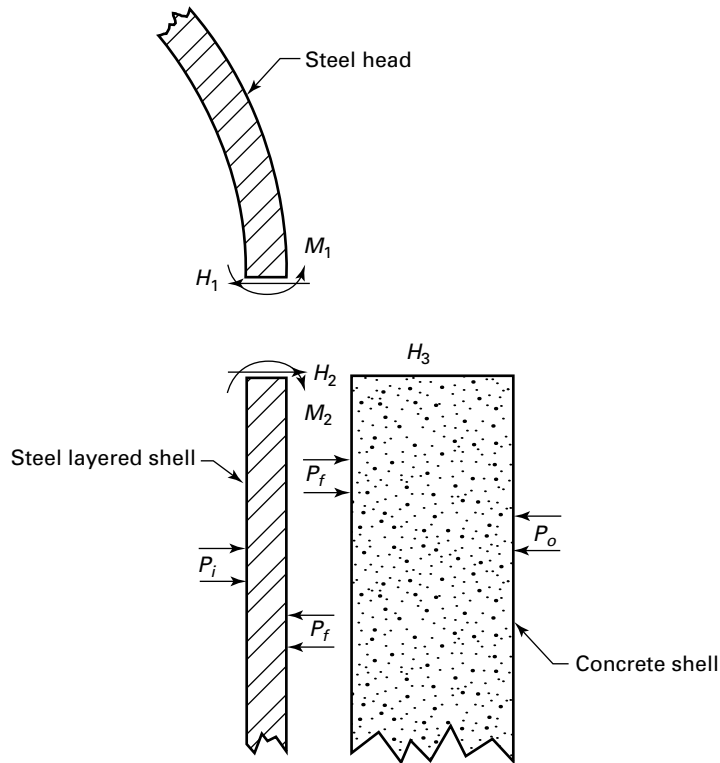


Figure 12
Head-to-Shell Forces



Case 2951

Alternative Approach for Operating Conditions (Including Occasional Loads) in the Time-Dependent Regime

Section VIII, Division 1

Approval Date: March 13, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an alternative approach be used for Section VIII, Division 1 construction of pressure vessels with operating conditions (including occasional loads) in the time-dependent regime?

Reply: It is the opinion of the Committee that a pressure vessel may be designed using an alternative approach for materials operating in the time-dependent regime for Section VIII, Division 1 construction under the following conditions:

(a) This Case shall only be used with agreement between owner/user (or owner/user and designated agent) and Manufacturer.

(b) The following definitions shall apply:

creep regime: temperature values identified by an alternative typeface in Section II, Part D, Table 1A [see General Note (f)] or Table 1B [see General Note (e)]. This temperature range signals a time-dependency when determining allowable stress, so is therefore synonymous with “time-dependent regime.”

life fraction: the sum of the ratios of actual duration of each operating condition to its associated allowable duration.

occasional loads: short-duration (no more than a total of 10 hr during the life of the equipment that occur coincidentally while the metal temperature is in the creep regime, unless the requirements of (g) are met) loads for which creep should not be a design consideration, but instead should be governed by yield and tensile properties.

transition temperature: the highest temperature for which the allowable stress is provided in Section II, Part D that is not governed by creep properties.

(c) The following nomenclature shall apply:

C_{LMP} = Larson-Miller Constant, as defined in API 579-1/ASME FFS-1, 2016 Edition, para. 10B.2.2 and Table 10B.2 (Note that only U.S. Customary units may be used with this

table). The C_{LMP} for some of the more commonly used materials are as follows:

(1) low and medium carbon steel = 20

(2) C- $\frac{1}{2}$ Mo = 20

(3) $1\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo, $2\frac{1}{4}$ Cr-1Mo, 5Cr- $\frac{1}{2}$ Mo, 9Cr-1Mo = 20

(4) Types 304, 304H, 316, 316H, 316L, 321, 321H, 347, and 347H = 15

λ_i = life fraction for a specified operating condition, i , which is taken as the ratio of actual duration, t_i , to allowable duration, $(t_{all})_i$

Δ = sum of each life fraction, λ_i , for each operating condition, i

LMP = Larson-Miller Parameter

P_i = pressure for each elevated temperature operating condition, i (psig)

S = allowable stress, psi, at design temperature per Section II, Part D, Table 1A when the rules in (h) are used for Occasional Load evaluation. When using the rules in (n), S is defined as the allowable stress at the designated operating temperature in the creep regime per Section II, Part D, Table 1A or Table 1B for the specified operating condition.

S_{occ} = occasional load allowable stress at design temperature in the creep regime, psi

S_{UTS} = tensile strength values, psi, for ferrous and nonferrous materials for a given temperature as defined in Section II, Part D, Subpart 1, Table U. Where the operating temperature exceeds the limits published in Table U, the tensile strength values in API 579-1/ASME FFS-1, 2016 Edition, para. 2E.2.1.3 and its associated tables may be used. When the method in API 579-1/ASME FFS-1, 2E.2.1.3 is used, the calculated tensile strength shall be equal to or less than the tensile strength at the maximum published temperature in Section II, Part D.

S_y = yield strength values, psi, for ferrous and nonferrous materials for a given temperature as defined in Section II, Part D, Subpart 1, Table Y-1. Where the operating temperature exceeds the limits published in Table Y-1, the yield strength values in API 579-1/ASME FFS-1, 2016 Edition, para. 2E.2.1.2 and its associated

tables may be used. When the method in API 579-1/ASME FFS-1, 2E.2.1.2 is used, the calculated yield strength shall be equal to or less than the yield strength at the maximum published temperature shown in Section II, Part D.

- SMYS = specified minimum yield strength, psi
- $(t_{all})_i$ = allowable time duration, hr, for a specified elevated temperature operating condition, i
- t_i = actual time duration, hr, (as specified by Owner/User) for each specified operating condition, including those conditions not in the creep regime, i
- T_i = temperature, °F, for each specified elevated temperature operating condition, i
- T_{Di} = temperature, °F, from Section II, Part D where the calculated stress, σ_i , equals the allowable stress in Section II, Part D for each specified operating condition, i
- σ_i = calculated stress, psi, for a specified operating condition, i

(d) For pressure vessels operating in the creep regime, this Case provides an alternative approach to creep design for the following load cases:

(1) *Occasional Loads.* Short-duration loads (e.g., earthquake and/or wind), in combination with other loadings in UG-22. The total duration of all of these occasional loads shall be limited to a maximum of 10 hr during the life of the equipment when the metal temperature is in the creep regime unless the requirements of (g) are met.

(2) *Time-Dependent Design Considering Creep.* One or more operating conditions where duration of the applied load(s) for the operating condition(s) in the creep regime may be considered in creep design.

When either of the load cases defined above utilize the methodology in (i), the user or designated agent shall be responsible for defining the various operating conditions to which the vessel will be subjected, including the duration for each operating condition. Section VIII, Division 1, Nonmandatory Appendix KK and the following may be used to capture the load cases when documenting the User’s Design Requirements:

Operating Condition	Operating Pressure, P_i , psig	Operating Temperature, T_i , °F	Duration t_i , hr
#1	P_1	T_1	t_1
#2	P_2	T_2	t_2
#X	P_x	T_x	t_x

GENERAL NOTE: When specifying the duration for an operating condition, a realistic duration that reflects the useful life of the equipment should be used. For example, if the equipment design life is 40 years and the operating condition (in the creep regime) under consideration could occur approximately 40% of the time, the duration specified for the operating condition should be 140,160 hr (i.e., 40 years x 365 days/year x 24 hr/day x 40%).

(e) For components assessed using the provisions of (d)(2), the minimum required test pressure shall be determined using either UG-99 or UG-100, with the following modifications.

(1) For hydrostatic tests in accordance with UG-99, the minimum test pressure shall be calculated using UG-99(c). The test pressure shall be reduced as necessary to ensure the general primary membrane stress level does not exceed 90% of SMYS.

(2) For pneumatic tests in accordance with UG-100, the minimum test pressure shall be calculated as 1.1 times the basis for the calculated test pressure as defined in Section VIII, Division 1, Mandatory Appendix 3, section 3-2. The test pressure shall be reduced as necessary to ensure the general primary membrane stress level does not exceed 90% of SMYS.

(f) The alternative rules provided in this Case cannot be applied to materials above their respective maximum temperature limits specified in Section II, Part D, Table 1A or Table 1B.

(g) The rules in (h) for occasional loads are specifically limited to the following materials from Section II, Part D, Table 1A: P-No. 1, P-No. 3, P-No. 4, P-No. 5A, P-No. 5C, and all 300 series stainless steels. For these materials, if the owner/user or designated agent determines that the total duration of the occasional loads over the life of the equipment while in the creep regime exceeds 10 hr, the methodology in (i) shall be used. Other materials not listed in this paragraph for which occasional loads are to be assessed shall meet the requirements of (i) as well. When the methodology in (i) is used for occasional loads, the resultant life fraction sum, Δ , for all occasional loads shall be less than or equal to 0.2.

(h) The allowable stress for occasional loads, S_{occ} , applied in the creep regime shall be obtained from Table 1. Since occasional loads such as wind and earthquake result in net-section tensile and compressive bending stresses on a pressure vessel, Table 1 provides allowable tensile stresses only. This Case shall not be used for determining allowable compressive stresses. For determining the allowable compressive stress, Section VIII, Division 1, UG-23(d) shall apply.

(i) The following alternative design approach may be used for multiple operating conditions where the duration of the applied load(s) for the operating condition(s) in the

Table 1
Alternative Allowable Tensile Stress Values for Occasional Loads in the Creep Regime

Product/Material	S_{occ}
300 series stainless steels	Max.[1.2S, Min.(S_y ,4S)]
P-No. 1, P-No. 3, P-No. 4, P-No. 5A, and P-No. 5C materials	Max.[1.2S, Min.(0.64 S_y ,4S)]

creep regime may be considered in creep design. This approach shall not be applied where use of time-dependent properties governing the allowable stress is specifically prohibited in the Code (e.g., UHX elastic-plastic methodology, etc.). This approach requires consideration of operating conditions, which are the expected combinations of actual operating pressures and coincident metal temperatures. A design pressure and design temperature are still required to establish the minimum required wall thickness of the pressure vessel. However, this approach will allow for some high-temperature events of a specified duration not to govern in setting those design conditions. One or more components of the pressure vessel may be designed per the following procedure:

(1) Calculate the stresses, σ_i , per (n) and Table 2 for the applicable components at each specified operating condition in the creep regime with duration, t_i , pressure, P_i , and temperature, T_i .

(2) Confirm the calculated stress in (1) is less than or equal to the smaller of the factored yield strength or the tensile strength divided by 3.5 at temperature, T_i . The factored yield strength is $2/3 \cdot S_y$ for ferritic materials and $0.9 \cdot S_y$ for austenitic materials at temperature, T_i . If these limits are exceeded, the component thickness shall be adjusted so that the calculated stress falls within this limit.

(3) Determine the temperature, T_{Di} , from Section II, Part D, Table 1A or Table 1B for which each calculated stress in (1) would equal the applicable table's allowable stress.

(4) Calculate the LMP for each operating condition based on T_{Di} with a duration of 100,000 hr based on the guidance provided in API 579-1/ASME FFS-1, 2016 Edition, para. 10B.2.2. In terms of the variables used within this Case, the formula is as follows:

$$\begin{aligned} & \text{LMP}(t_{100,000}, T_{Di})_i \\ &= \frac{(T_{Di} + 460) \left[C_{\text{LMP}} + \text{Log}_{10}(100,000) \right]}{1,000} \\ &= \frac{(T_{Di} + 460)(C_{\text{LMP}} + 5)}{1,000} \end{aligned}$$

(5) Using the LMP that was determined in (4), calculate an allowable duration, $(t_{\text{all}})_i$ for the actual temperature, T_i , of the operating condition using the API 579-1/ASME FFS-1 guidance referenced in (4). In terms of the variables used within this Case, the formula is as follows:

$$\begin{aligned} \text{LMP}_i &= \frac{(T_i + 460) \left\{ C_{\text{LMP}} + \text{Log}_{10}[(t_{\text{all}})_i] \right\}}{1,000} \\ (t_{\text{all}})_i &= 10 \exp \left[\left(\frac{1,000 \cdot \text{LMP}_i}{T_i + 460} \right) - C_{\text{LMP}} \right] \end{aligned}$$

(6) Compute the life fraction, λ_i , for each operating condition:

$$\lambda_i = t_i / (t_{\text{all}})_i$$

(7) The component design, considering all operating conditions in the creep regime, is acceptable if the life fraction sum, Δ , is less than or equal to 0.8.

The Δ limit of 0.8 ensures that an overall limit of 1 is maintained if longitudinal stress governs the design and the maximum occasional load life fraction limit of 0.2 is used as specified in (g). If calculations per (i) are performed for occasional loads, the limit on Δ may be increased above 0.8 as long as the life fraction sum for all operating conditions in the creep regime, including occasional loads, is less than or equal to 1.0.

A life fraction sum limit of 0.8 is recognized as conservative when the stresses due to occasional loads occur in a different direction than the governing stress (e.g., cylinder hoop stress being greater than the longitudinal stress resulting from pressure plus wind loads). In this case, the Δ limit may be increased to 1.0 for the respective component.

(j) The following guidance shall be used in determining the design conditions for the pressure vessel:

(1) Design pressure shall be based on the highest operating pressure from all conditions. The design pressure shall be used in establishing the pressure relief requirements. Consideration shall be given to use of a user-specified factor on operating pressure consistent with the recommendations contained in Endnote 11 of Section VIII, Division 1 (2017 edition).

(2) Design temperature shall be based on the longest duration operating condition temperature.

(3) If one or more short-term operating condition temperatures exceed the vessel's design temperature established in (2), the requirements of UG-140, including the use of protective instrumentation as allowed in UG-140(b)(4) shall be met.

(k) When the temperature, T_i , for an operating condition falls at or below the transition temperature, this condition shall not be considered in the life fraction calculation in (i).

(l) When the calculated stress, σ_i , for an operating condition in (i)(1) has an associated Table 1A or Table 1B allowable stress from (i)(3) that is greater than the allowable stress at the transition temperature [i.e., the resultant T_{Di} in (i)(3) is in the time-independent range], the procedure in (i) shall be followed.

(m) When the calculated stress for an operating condition in (i)(1) is less than the stress at the highest temperature for which allowable stresses are provided in Section II, Part D, Table 1A or Table 1B, the maximum published temperature from the applicable table shall be used to calculate the LMP in (i)(4).

(n) Table 2 shall be used to calculate the stress, σ_i , for each component as required in (i)(1). σ_i shall be calculated for each component at each specified operating condition in the creep regime. Some components will require evaluation of multiple σ_i values (e.g., tubesheet bending and shear stresses).

(o) Where the methodology in (h) has been used, the Owner/User is not required to monitor the duration of occasional loads over the life of the equipment. However, where the methodology in (i) has been used for one or more operating conditions [including occasional loads per (g)], monitoring of both frequency and duration of all operating conditions in the creep regime is required.

(p) Creep-fatigue interaction effects shall be considered when the number of cycles exceeds 100. Cycle counting shall be based on the method described in Section VIII, Division 2, Part 5, 5.5.2.3.

(q) The vessel or vessel components designed using these rules shall be noted on the Manufacturer's Data Report (MDR). The "Remarks" section of the MDR shall contain the associated operating pressure, operating temperature, and duration for each condition used in the equipment design.

(r) All other requirements for construction shall comply with Section VIII, Division 1.

(s) This Case number shall be shown on the Manufacturer's Data Report.

(t) *References*

[1] ASME STP-PT-024, Development of Basic Time-Dependent Allowable Stresses for Creep Regime in Section VIII, Division 1

[2] API 579-1/ASME FFS-1, Fitness-For-Service, 2016

[3] ASME Boiler and Pressure Vessel Code, 2017, Section VIII, Division 1, Rules for Construction of Pressure Vessels

[4] ASME Boiler and Pressure Vessel Code, 2017, Section VIII, Division 2, Rules for Construction of Pressure Vessels, Alternative Rules

[5] ASME Boiler and Pressure Vessel Code, 2017, Section II, Part D, Materials, Properties

[6] Cases of ASME Boiler and Pressure Vessel Code, Boilers and Pressure Vessels, Case 2695, Allowing Section VIII, Division 2 Design Rules to Be Used for Section VIII, Division 1 Pressure Vessel

Table 2
Methods for Calculating Component Stress, σ_i , as Required in (i)(1)

Vessel Component [Note (1)], [Note (2)], [Note (3)]	Calculated Stress Basis	Calculated Stress, σ_i
Shells under internal pressure	Section VIII, Division 1, UG-27 or Mandatory Appendix 1	S in UG-27; alternatively, the formulas in Mandatory Appendix 1, section 1-1, 1-2, or 1-3 may be used as appropriate
Formed heads, and sections, with pressure on concave side	Section VIII, Division 1, UG-32 or Mandatory Appendix 1	S in UG-32; alternatively, the formulas in Mandatory Appendix 1, section 1-4 may be used as appropriate
Cylindrical-to-conical shell transition junctions without a knuckle	Code Case 2695 and Section VIII, Division 2, 4.3.11	$[\sigma_{sm}/0.25]$ for large-end junction
		$[\sigma_{sm}/1.25]$ for small-end junction
		$[(\sigma_{sm} \pm \sigma_{sb})/2]$ for large-end junction
		$[(\sigma_{sm} \pm \sigma_{sb})/2]$ for small-end junction
		$[\sigma_{\theta m}/1.25]$ for large-end junction
		$[\sigma_{\theta m}/1.25]$ for small-end junction
		$[(\sigma_{\theta m} \pm \sigma_{\theta b})/2]$ for large-end junction $[(\sigma_{\theta m} \pm \sigma_{\theta b})/2]$ for small-end junction
Cylindrical-to-conical shell transition junctions with a knuckle	Code Case 2695 and Section VIII, Division 2, 4.3.12	σ_{sm}
		$\sigma_{\theta m}$
Unstayed flat heads and covers	Section VIII, Division 1, UG-34	$1.2S$, where S is defined in UG-34
Openings in shells and heads under internal pressure	Code Case 2695 and Section VIII, Division 2, 4.5; allowable stress values used in calculation of the f_x factors shall be determined in accordance with this Case	$P_L/1.25$
U-tube tubesheets	Section VIII, Division 1, UHX-12	$\sigma/1.67$
		1.25τ
		$[\sigma_c/1.25]$ and/or $[\sigma_s/1.25]$ for U-tube tubesheets with welded channels and/or shells
Fixed tubesheets [Note (4)], [Note (5)]	Section VIII, Division 1, UHX-13	$\sigma/1.25$
		1.25τ
		$[\sigma_c/1.25]$ and/or $[\sigma_s/1.25]$ for fixed tubesheets with welded channels and/or shells, when considering design loading cases
		$[\sigma_c/2]$ and/or $[\sigma_s/2]$ for fixed tubesheets with welded channels and/or shells, when considering operating loading cases
Floating tubesheets [Note (4)]	Section VIII, Division 1, UHX-14	$\sigma/1.25$
		1.25τ
		$[\sigma_c/1.25]$ and/or $[\sigma_s/1.25]$ for floating tubesheets with welded channels and/or shells, when considering design loading cases
		$[\sigma_c/2]$ and/or $[\sigma_s/2]$ for floating tubesheets with welded channels and/or shells, when considering operating loading cases
Dished covers (bolted heads)	Section VIII, Division 1, Mandatory Appendix 1, section 1-6	S in Mandatory Appendix 1, section 1-6 for heads
		S in Mandatory Appendix 1, section 1-6 for flanges

**Table 2
Methods for Calculating Component Stress, σ_i , as Required in (i)(1) (Cont'd)**

Vessel Component [Note (1)], [Note (2)], [Note (3)]	Calculated Stress Basis	Calculated Stress, σ_i
Bolted flange connections (integral type flanges, optional type flanges calculated as integral, and loose type flanges with a hub which is considered) [Note (6)], [Note (7)]	Section VIII, Division 1, Mandatory Appendix 2	Longitudinal hub stress, $S_H/1.25$
		Radial flange stress, S_R
		Tangential flange stress, S_T
		Maximum of $[(S_H + S_R)/2]$ or $[(S_H + S_T)/2]$
Bolted flange connections (loose type flanges without hubs, loose type flanges with a hub which is not considered, and optional type flanges calculated as loose type) [Note (6)], [Note (7)]	Section VIII, Division 1, Mandatory Appendix 2	Tangential flange stress, S_T
Jacketed vessels	Section VIII, Division 1, Mandatory Appendix 9	S in UG-27 for shells under internal pressure; alternatively, the formulas in Mandatory Appendix 1, section 1-1, 1-2, or 1-3 may be used as appropriate
		$1.2S$ in Mandatory Appendix 9 for jacket closure bars
Vessels of noncircular cross section	Section VIII, Division 1, Mandatory Appendix 13	Membrane stress in Mandatory Appendix 13
		[Total stress/1.25] in Mandatory Appendix 13

NOTES:

- (1) Components subjected to external pressure or other compressive loads shall be evaluated at all temperature and pressure combinations; the alternative rules in this Case do not apply.
- (2) Flanges constructed to ASME B16.5 or ASME B16.47 shall be evaluated at all temperature and pressure combinations; the alternative rules in this Case do not apply.
- (3) This Case only applies to components that are listed in this Table. For example, threaded connections, braced and stayed surfaces, plug welded components, clamp connections, bellows expansion joints, and socket welded components are outside the scope of this Case. Additionally, application of Mandatory Appendix 32 to address local thin areas are also outside the scope of this Case.
- (4) For fixed or floating tubesheets, tube axial stresses (tensile and/or compressive) shall be evaluated at the specified operating temperature; the alternative rules in this Case do not apply.
- (5) For fixed tubesheets, shell compressive stresses (if applicable) shall be evaluated at the specified operating temperature; the alternative rules in this Case do not apply.
- (6) The bolting allowable stress used in the flange calculations shall be the value from Section II, Part D at the largest elevated temperature; the alternative rules in this Case do not apply.
- (7) The flange rigidity factor in the operating condition shall be evaluated at the largest elevated design temperature condition using the design pressure of the flange; the alternative rules in this Case do not apply.

NONMANDATORY APPENDIX A EXAMPLE PROBLEMS

A-1 EXAMPLE 1: USE OF THE OCCASIONAL LOAD ALTERNATIVE ALLOWABLE STRESS CRITERIA

(a) *Input:* a pressure vessel has the following design details:

- (1) material: SA-516-70 (P-No. 1 material)
- (2) design temperature: 800°F
- (3) allowable stress, S , at 800°F (Section II, Part D, Table 1A): 12,000 psi
- (4) yield strength, S_y , at 800°F (Section II, Part D, Table Y-1): 25,500 psi
- (5) occasional loads: wind and earthquake (<10 hr in the life of the equipment)

(b) *Question:* what is the allowable tensile stress when considering wind and/or earthquake, with all other applicable loads per Section VIII, Division 1, UG-22?

(c) *Solution:* per [Table 1](#), for P-No. 1 material, the allowable tensile stress when considering occasional loads in the creep regime is as follows:

$$\text{Max.} \left[1.2S, \text{Min.} \left(0.64 \cdot S_y, 4S \right) \right]$$

Therefore, using the input provided, the allowable tensile stress is as follows:

$$\text{Max.} [1.2 \cdot 12,000, \text{Min.} (0.64 \cdot 25,000, 4 \cdot 12,000)] = 16,320 \text{ psi}$$

A-2 EXAMPLE 2: USE OF THE OCCASIONAL LOAD ALTERNATIVE ALLOWABLE STRESS CRITERIA

(a) *Input:* a pressure vessel has the following design details:

- (1) material: SA-240-304L
- (2) design temperature: 1,000°F
- (3) allowable stress, S , at 1,000°F (Section II, Part D, Table 1A): 7,800 psi
- (4) yield strength, S_y , at 1,000°F (Section II, Part D, Table Y-1): 13,300 psi
- (5) occasional loads: wind and earthquake (<10 hr in the life of the equipment)

(b) *Question:* what is the allowable tensile stress when considering wind and/or earthquake, with all other applicable loads per Section VIII, Division 1, UG-22?

(c) *Solution:* per [Table 1](#) of the Code Case, for 300 series stainless steel material, the allowable tensile stress when considering occasional loads in the creep regime is as follows:

$$\text{Max.} \left[1.2S, \text{Min.} \left(0.64 \cdot S_y, 4S \right) \right]$$

Therefore, using the input provided, the allowable tensile stress is as follows:

$$\text{Max.} [1.2 \cdot 7,800, \text{Min.} (13,300, 4 \cdot 7,800)] = 13,300 \text{ psi}$$

A-3 EXAMPLE 3: USE OF THE ALTERNATIVE DESIGN APPROACH FOR TIME-DEPENDENT DESIGN CONSIDERING CREEP

(a) *Input:* a pressure vessel cylinder has the following set of design criteria:

- (1) material: SA-387, Gr. 11, Class 2 [$1\frac{1}{4}\text{Cr}-\frac{1}{2}\text{Mo}-\text{Si}$]
- (2) vessel O.D: 160 in.
- (3) joint efficiency, E : 100%
- (4) shell thickness: TBD
- (5) no static head
- (6) corrosion allowance: 0.0625 in.

(7) operating conditions are as follows:

Operating Condition No.	Duration, t_i , hr	Operating Pressure, P_i , psig	Operating Temperature, T_i , °F
1	10,000	545	1,025
2	100,000	590	975

(b) Question: what are the design conditions and the shell required thickness, t_{req} , for the above input?

(c) Solution 1: Determine t_{req} based upon the standard methodology in Section VIII, Division 1, UG-27 (assume hoop stress governs the required thickness).

First, establish the design pressure and design temperature for the pressure vessel. Typically, the design pressure is established by applying a user-specified factor on operating pressure. For this example a factor of 1.1 shall be used. Likewise, a margin on operating temperature is commonly specified by the user. For this example, a margin of 50°F shall be used on the operating temperature.

Applying the factor on pressure and margin on temperature for the operating conditions defined above, the following results are obtained:

Operating Condition No.	Duration, t_i , hr	Operating Pressure, P_i , psig	Design Pressure, DP_i , psig	Operating Temperature, T_i , °F	Design Temperature, DT_i , °F
1	10,000	545	600	1,025	1,075
2	100,000	590	650	975	1,025

For this example, assume that hoop stress governs the required thickness for this pressure vessel, so thickness calculations pertaining to longitudinal stress will not be performed. Since the vessel thickness is unknown, required thickness calculations using the OD-basis in Mandatory Appendix 1, section 1-1 shall be used:

$$t_{req} = \frac{PR_o}{SE + 0.4P} + CA$$

Application of the equation above requires that each design condition be assessed separately to determine which condition governs the required thickness. The results are as follows:

Condition No.	Design Pressure, psig	Design Temperature, °F	Allowable Stress, psi	t_{req} , in.
1	600	1,075	3,500	12.9
2	650	1,025	5,250	9.5

Therefore, Condition 1 governs the design with a $t_{req} = 12.9$ in. Although Condition 1 governs the required thickness, both conditions must be reflected as the design conditions for this vessel, since the vessel pressure relief valve (PRV) must be set to 650 psig to prevent PRV simmering and premature liftoff. Controls must be put in place to prevent vessel overpressure if the temperature exceeds 1,025°F.

(d) Solution 2: Determine t_{req} using a revised basis for establishing the design conditions and with use of the alternative allowable stress method of this Appendix.

Establish the design conditions using the following approach: Design pressure shall be based on the highest operating pressure from all conditions, and the design temperature shall be based on the longest-duration condition. The same margins are applied to the temperatures and pressures for each operating condition as shown in the following:

Operating Condition No.	Duration, t_i , hr	Operating Pressure, P_i , psig	Design Pressure, DP_i , psig	Operating Temperature, T_i , °F	Design Temperature, DT_i , °F
1	10,000	545	600	1,025	1,075
2	100,000	590	650	975	1,025

In this example, the highest design pressure comes from Condition 2 and the longest duration condition is also Condition 2, so this results in the following design conditions: design pressure = 650 psig; design temperature = 1,025°F.

With a vessel design pressure of 650 psig, the safety valve set pressure will be 650 psig. Since none of the operating conditions require an operating temperature above the design temperature of 1,025°F, no additional controls are required.

Calculate the minimum required shell thickness based on the design conditions defined above using the Mandatory Appendix 1, section 1-1 OD-basis.

$$t_{\text{req}} = \frac{PR_o}{SE + 0.4P} + CA = \frac{(650)(80)}{(5,250)(1) + 0.4(650)} + 0.0625 = 9.50 \text{ in.}$$

Based on the calculation above, a tentative shell thickness of 9.5 in. will be used in the design evaluation.

Step 1. Calculate the stress, σ_i , for each specified operating condition in the creep regime with duration, t_i , and temperature, T_i . For operating conditions at temperatures below the creep regime, such conditions shall not be considered in this alternative approach.

Using a corroded shell thickness of 9.44 in. (i.e., 9.50–0.0625), Section VIII, Division 1, UG-27 shall be used to calculate σ_i for each condition:

$$\sigma_i = \frac{P_i(R + 0.6t)}{Et}$$

Condition No.	Operating Pressure, P_i , psig	Operating Temperature, T_i , °F	Calculated Stress, σ_i , psi
1	545	1,025	4,402
2	590	975	4,765

Step 2. Confirm the calculated stress does not exceed the smaller of $\frac{2}{3} * S_y$ (for ferritic materials) and $S_{UTS}/3.5$ at temperature, T_i as shown as follows:

Condition No.	Operating Temperature, T_i , °F	Calculated Stress, σ_i , psi	$\frac{2}{3} * S_y$, psi	$S_{UTS}/3.5$, psi
1	1,025	4,402	18,800	12,774
2	975	4,765	19,200	18,100

Since the operating temperature for Condition 1 exceeds the temperature limits for yield and tensile strengths in Section II, Part D, Tables Y-1 and U, the yield and tensile strengths were determined using API 579, paras. 2E.2.1.2 and 2E.2.1.3. The results indicate $S_y = 29,124$ psi and $S_{UTS} = 44,709$ psi at 1,025°F. However, as stipulated in (c), nomenclature for S_y , the API 579 calculated yield strength must be less than or equal to the value at the maximum published temperature in Section II, Part D, Table Y-1, so the value used in this example is $(S_y)_{@1,000^\circ\text{F}} = 28,200$ psi.

The yield and tensile strengths for Condition 2 were obtained from Section II, Part D, Tables Y-1 and U. The calculated stresses are less than the smaller of $\frac{2}{3} * S_y$ and $S_{UTS}/3.5$ and are therefore acceptable for continued evaluation.

Step 3. Determine the temperature, T_{Di} , from the applicable allowable stress table (Section II, Part D, Table 1A) for which each calculated stress in [Step 1](#) would equal the allowable stress.

In this example, for a calculated stress of 4,402 psi corresponding to σ_1 , the following reflects the data used to linearly interpolate to obtain the resultant temperature, T_{D1} (the same methodology is used to determine the temperature, T_{D2} , for a calculated stress of 4,765 psi):

- (a) Temp₁ (°F): 1,000; Allowable Stress₁ (psi): 6,300
- (b) Temp₂ (°F): T_{Di} ; Calculated Stress₂ (psi): 4,402
- (c) Temp₃ (°F): 1,050; Allowable Stress₃ (psi): 4,200
- (d) T_{D1} (°F): 1,045; T_{D2} (°F): 1,037

Step 4. Calculate the LMP for each condition based on T_{Di} with a duration of 100,000 hr, using the guidance provided in API 579-1/ASME FFS-1, 2016 Edition, para. 10B.2.2. In terms of the variables used in this Case, the formula is as follows:

$$\text{LMP}(t_{100,000}, T_{Di})_i = \frac{(T_{Di} + 460) \left[C_{\text{LMP}} + \text{Log}_{10}(100,000) \right]}{1,000}$$

With a $C_{LMP} = 20.0$, the LMP for each condition is as follows:

Condition No.	C_{LMP}	T_{Di} , °F	LMP _i
1	20.0	1,045	37.63
2	20.0	1,037	37.43

Step 5. Using the LMP determined in [Step 4](#), calculate an allowable duration, $(t_{all})_i$ for the actual temperature, T_i , of the operating condition using the guidance provided in API 579-1/ASME FFS-1, 2016 Edition, para. 10B.2.2.

$$(t_{all})_i = 10 \exp \left[\left(\frac{1,000 \cdot LMP_i}{T_i + 460} \right) - C_{LMP} \right]$$

Condition No.	T_i , °F	C_{LMP}	LMP _i	$(t_{all})_i$, hr
1	1,025	20.0	37.63	217,120
2	975	20.0	37.43	1,202,650

Step 6. Compute the life fraction, λ_i , for each operating condition:

$$\lambda_i = t_i / (t_{all})_i$$

Condition No.	T_i , °F	P_i , psig	t_i , hr	$(t_{all})_i$	λ_i
1	1,025	545	10,000	217,120	0.046
2	975	590	100,000	1,202,650	0.083

Step 7. Determine if the design, considering all operating conditions in the creep regime, is acceptable if the following requirement is met:

$$\Delta = \sum \lambda_i \leq 1$$

A limit of 1 was used under the assumption that hoop stress governed the design. Had longitudinal stress governed, a limit of 0.8 would have been used, in order to permit any occasional loads applied to the design to consume up to a life fraction of 0.2.

The sum, Δ , is 0.129, which is less than 1, so this design using a shell required thickness, t_{req} , of 9.5 in., a design pressure of 650 psig, and a design temperature of 1,025°F is considered acceptable.

A-4 EXAMPLE 4: USE OF THE ALTERNATIVE DESIGN APPROACH FOR TIME-DEPENDENT DESIGN CONSIDERING CREEP

(a) *Input:* consider a pressure vessel cylinder with the following set of design criteria:

(1) material: SA-516-70 (carbon steel)

(2) vessel ID: 270 in.

(3) joint efficiency, E : 85%

(4) thickness: TBD

(5) corrosion allowance: none (corrosion resistant overlay will be installed on ID surface and will not be included in calculating the vessel stresses)

(6) design and operating conditions (supplied by User):

Operating Condition No.	Duration, t_i , hr	Operating Pressure, P_i , psig	Design Pressure, DP_i , psig	Operating Temperature, T_i , °F	Design Temperature, DT_i , °F
1	20,000	40	45	350	400
2	100,000	37	45	750 [Note (1)]	750
3	1,000	41	45	1,000 [Note (2)]	1,000

NOTES:

(1) Actual operating temperature is 725°F, but User specified 750°F for conservatism.

(2) Actual operating temperature is 975°F, but User specified 1,000°F for conservatism.

(b) Question: what is the required thickness, t_{req} , for the above input, assuming that hoop stress governs the design?

(c) Solution: Calculate the minimum required shell thickness based on the highest design pressure (45 psi) and the design temperature (750°F) corresponding to the longest duration condition using the UG-27 ID-basis formula.

$$t_{req} = \frac{PR_i}{SE - 0.6P} + CA = \frac{(45)(135)}{(14,800)(0.85) - 0.6(45)} + 0 = 0.484 \text{ in.}$$

where S was obtained from Section II, Part D for SA-516-70 at 750°F. Rounded to the nearest $\frac{1}{8}$ in., the thickness used in design is 0.5 in.

Step 1. Calculate the stress, σ_i , for each specified operating condition in the creep regime with duration, t_i , and temperature, T_i . For operating conditions at temperatures below the creep regime, such conditions shall not be considered in this alternative approach.

Section VIII, Division 1, UG-27 shall be used to calculate σ_i for each condition:

$$\sigma_i = \frac{P_i(R + 0.6t)}{Et}$$

Condition No.	Operating Pressure, P_i , psig	Operating Temperature, T_i , °F	Calculated Stress, σ_i , psi
2	37	750	11,779
3	41	1,000	13,053

Step 2. Confirm the calculated stress does not exceed the smaller of $\frac{2}{3}S_y$ (for ferritic materials) and $S_{UTS}/3.5$ at temperature, T_i .

Condition No.	Operating Temperature, T_i , °F	Calculated Stress, σ_i , psi	$\frac{2}{3}S_y$, psi	$S_{UTS}/3.5$, psi
2	750	11,779	17,533	19,743
3	1,000	13,053	15,067	11,543

The yield and tensile strengths were obtained from Section II, Part D, Tables Y-1 and U. Although the calculated stresses are less than $\frac{2}{3}S_y$, the calculated stress of 13,053 psi for Condition 3 is greater than $S_{UTS}/3.5$ (11,543 psi), so the design is not acceptable for continued evaluation.

In order to meet the above requirements, set the design thickness equal to 0.75 in. and increase the amount of nondestructive examination to generate a joint efficiency $E=1$, then repeat the process beginning with Step 1 and Step 2 [as shown, respectively, in (a) and (b) below].

(a) Calculate the stress, σ_i , for each specified operating condition in the creep regime with duration, t_i , and temperature, T_i . For operating conditions at temperatures below the creep regime, such conditions shall not be considered in this alternative approach.

Section VIII, Division 1, UG-27 shall be used to calculate σ_i for each condition:

$$\sigma_i = \frac{P_i(R + 0.6t)}{Et}$$

Condition No.	Operating Pressure, P_i , psig	Operating Temperature, T_i , °F	Calculated Stress, σ_i , psi
2	37	750	6,682
3	41	1,000	7,405

(b) Confirm the calculated stress does not exceed the smaller of $\frac{2}{3}S_y$ (for ferritic materials) and $S_{UTS}/3.5$ at temperature T_i .

Condition No.	Operating Temperature, T_i , °F	Calculated Stress, σ_i , psi	$\frac{2}{3}S_y$, psi	$S_{UTS}/3.5$, psi
2	750	6,682	17,533	19,743
3	1,000	7,405	15,067	11,543

The yield and tensile strengths were obtained from Section II, Part D, Tables Y-1 and U. Although the calculated stresses are less than $\frac{2}{3}S_y$, the calculated stress of 13,053 psi for Condition 3 is greater than $S_{UTS}/3.5$ (11,543 psi), so the design is not acceptable for continued evaluation.

Step 3. Determine the temperature, T_{Di} , from the applicable allowable stress table (Section II, Part D, Table 1A) for which each calculated stress in Step 2(a) would equal the allowable stress.

In this example, for a calculated stress of 6,682 psi corresponding to σ_2 , the following reflects the data used to linearly interpolate to obtain the resultant temperature, T_{D2} (the same methodology is used to determine the temperature, T_{D3} , for a calculated stress of 7,405 psi):

(a) Temp₁ (°F): 900; Allowable stress₁ (psi): 6,700

(b) Temp₂ (°F): T_{Di} ; Calculated stress₂ (psi): 6,682

(c) Temp₃ (°F): 950; Allowable stress₃ (psi): 4,000

(i) T_{D2} (°F): 900; T_{D3} (°F): 886

Step 4. Calculate the LMP for each condition based on T_{Di} with a duration of 100,000 hr, using the guidance provided in API 579-1/ASME FFS-1, 2016 Edition, para. 10B.2.2. In terms of the variables used within this Appendix, the formula is as follows:

$$LMP(t_{100,000}, T_{Di})_i = \frac{(T_{Di} + 460)[C_{LMP} + \text{Log}_{10}(100,000)]}{1,000}$$

With a $C_{LMP} = 20.0$ per Table 10B.2 of API 579-1/ASME FFS-1, the LMP for each condition is as follows:

Condition No.	Rupture Life, hr	C_{LMP}	T_{Di} , °F	LMP _i
2	100,000	20.0	900	34.00
3	100,000	20.0	886	33.65

Step 5. Using the LMP determined in Step 4, calculate an allowable duration, $(t_{all})_i$ for the actual temperature, T_i , of the operating condition using the guidance provided in API 579-1/ASME FFS-1, 2016 Edition, para. 10B.2.2.

$$(t_{all})_i = 10 \exp \left[\left(\frac{1,000 \cdot LMP_i}{T_i + 460} \right) - C_{LMP} \right]$$

Condition No.	T_i , °F	C_{LMP}	LMP _i	$(t_{all})_i$, hr
2	750	20.0	34.00	125,653,200
3	1,000	20.0	33.65	1,117

Step 6. Compute the life fraction, λ_i , for each operating condition:

$$\lambda_i = t_i / (t_{all})_i$$

Condition No.	T_i , °F	P_i , psig	T_i , hr	$(t_{all})_i$	λ_i
2	750	37	100,000	125,653,200	0.001
3	1,000	41	1,000	1,117	0.895

Step 7. Determine if the design, considering all operating conditions in the creep regime, is acceptable if the following requirement is met:

$$\Delta = \sum \lambda_i \leq 1$$

A limit of 1 was used under the assumption that hoop stress governed the design. Had longitudinal stress governed, a limit of 0.8 would have been used, in order to permit any occasional loads applied to the design to consume up to a life fraction of 0.2.

The sum, Δ , is 0.896, which is less than 1, so the cylinder design thickness of 0.75 in. is considered acceptable. This same evaluation must be performed for all other vessel components subjected to the operating conditions.

A-5 EXAMPLE 5: USE OF THE ALTERNATIVE DESIGN APPROACH FOR TIME-DEPENDENT DESIGN CONSIDERING CREEP

(a) *Input:* a heat exchanger shell has the following set of design criteria:

- (1) cylinder and head material: SA-516-70 [carbon steel]
- (2) girth flange material: SA-266 Grade 2 [carbon steel]
- (3) nozzle material: SA-105 [carbon steel]
- (4) nozzle reinforcement stress, $P_L = 19,476$ psi
- (5) tubesheet material: SA-336F11, Class 2 [$1\frac{1}{4}\text{Cr} - \frac{1}{2}\text{Mo-Si}$]
- (6) shell ID: 35 in.
- (7) nozzle ID: 9.56 in.
- (8) joint efficiency, E : 100%
- (9) thickness: TBD
- (10) flange stresses: $S_H = 19,245$ psi; $S_R = 4,032$ psi; $S_T = 12,644$ psi
- (11) U-tube tubesheet stresses: $\sigma = 35,171$ psi; $\tau = 10,601$ psi
- (12) initial corrosion allowance: 0.25 in.
- (13) design and operating conditions (supplied by User):

Operating Condition No.	Duration, t_i , hr	Operating Pressure, P_i , psig	Design Pressure, DP_i , psig	Operating Temperature, T_i , °F	Design Temperature, DT_i , °F
1	100,000	1,700	1,800	350	600
2	1,000	1,700	1,800	800 [Note (1)]	800

NOTE: (1) Actual operating temperature <800°F, so User specified 800°F as the design temperature.

(b) *Question:* what are the required thicknesses, t_{req} , for each component based on the above input?

(c) *Solution:* Calculate the minimum required shell thickness based on the highest design pressure (1,800 psi) from all conditions and the design temperature (600°F) from the longest duration condition using the UG-27 ID-basis formula.

$$t_{req} = \frac{PR_i}{SE - 0.6P} + CA = \frac{(1,800)(17.5 + 0.25)}{(19,400)(1) - 0.6(1,800)} + 0.25 = 1.994 \text{ in.}$$

Rounded to the nearest $\frac{1}{8}$ in., the thickness used in design is 2 in. Check the cylinder component first to ensure adequacy before proceeding to other components.

Step 1. Calculate the stress, σ_i , for each specified operating condition in the creep regime with duration, t_i , and temperature, T_i , for each set of conditions. For operating conditions at temperatures below the creep regime, such conditions shall not be considered in this alternative approach.

Section VIII, Division 1, UG-27 shall be used to calculate σ_i for each condition:

$$\sigma_i = \frac{P_i(R + 0.6t)}{tE}$$

Condition No.	Operating Pressure, P_i , psig	Operating Temperature, T_i , °F	Calculated Stress, σ_i , psi
2	1,700	800	18,263

Step 2. Confirm the calculated stress does not exceed the smaller of $\frac{2}{3}S_y$ (for ferritic materials) and $S_{UTS}/3.5$ at temperature, T_i .

Condition No.	Operating Temperature, T_i , °F	Calculated Stress, σ_i , psi	$\frac{2}{3}S_y$, psi	$S_{UTS}/3.5$, psi
2	800	18,263	17,000	18,371

The yield and tensile strengths were obtained from Section II, Part D, Tables Y-1 and U. The calculated stress is greater than the smaller of $\frac{2}{3}S_y$ and $S_{UTS}/3.5$, so this design is unacceptable. As a next step, maintain the cylinder thickness of 2 in., but reduce the CA to 0.125 in. The yield and tensile strengths were obtained from Section II, Part D, Tables Y-1 and U. The calculated stress is greater than the smaller of $\frac{2}{3}S_y$ and $S_{UTS}/3.5$, so this design is unacceptable. In order to meet the above requirements, maintain the cylinder thickness of 2 in., but reduce the CA to 0.125 in., then repeat the process beginning with Step 1 and Step 2 [shown, respectively, in (a) and (b) below].

(a) Calculate the stress, σ_i , for each specified operating condition in the creep regime with duration, t_i , and temperature, T_i , for each set of conditions. For operating conditions at temperatures below the creep regime, such conditions shall not be considered in this alternative approach.

Section VIII, Division 1, UG-27 shall be used to calculate σ_i for each condition:

$$\sigma_i = \frac{P_i(R + 0.6t)}{tE}$$

Condition No.	Operating Pressure, P_i , psig	Operating Temperature, T_i , °F	Calculated Stress, σ_i , psi
2	1,700	800	17,000

Since the calculated stress in the cylinder is now less than or equal to the smaller of $\frac{2}{3}S_y$ and $S_{UTS}/3.5$, proceed to determining the stresses, σ_i , for the other components. For this example, only one condition is in the creep regime. If multiple conditions were in the creep regime, a similar table as shown in Table A-1 must be created for each condition.

Note that SA-193 B16 bolts (≤ 2.5 in. diameter) were used for this example since the allowable stress is constant (25 ksi) through the maximum elevated temperature of 800°F. For comparison, if SA-193 B7 bolts had been used, an allowable stress of 21 ksi at 800°F would have been required for the operating condition in the Section VIII, Division 1, Mandatory Appendix 2 flange calculations. Additionally, the flange rigidity factor shall be evaluated at the largest elevated design temperature condition of 800°F using the design pressure of 1,800 psig.

The nozzle flange class shall be selected from ASME B16.5 based on design conditions of 1,800 psig at 800°F, which result in CL1500 flanges (i.e., flange rating of 2,055 psig at 800°F for Material Group 1.1).

(b) Confirm the calculated stress does not exceed the smaller of $\frac{2}{3}S_y$ (for ferritic materials) and $S_{UTS}/3.5$ at temperature T_i ; see Table A-2.

The yield and tensile strengths were obtained from Section II, Part D, Tables Y-1 and U. The calculated stresses are less than the smaller of $\frac{2}{3}S_y$ and $S_{UTS}/3.5$ and are therefore acceptable for continued evaluation.

Step 3. Determine the temperature, T_{Di} , from the applicable allowable stress table (Section II, Part D, Table 1A) for which each calculated stress in Step 2(a) would equal the allowable stress.

For a calculated stress of 17,000 psi corresponding to σ_2 for the cylinder, the following reflects the data used to linearly interpolate to obtain the resultant temperature, T_{D2} (the same methodology is used to determine the temperature, T_{D2} , for the other components):

- (a) Temp₁ (°F): 700; Allowable Stress₁ (psi): 18,100
- (b) Temp₂ (°F): T_{Di} ; Calculated Stress₂ (psi): 17,000
- (c) Temp₃ (°F): 750; Allowable Stress₃ (psi): 14,800

Component	T_{D2} (°F)
Cylinder	717
2:1 Ellipsoidal head	730
Nozzles	738
Tubesheet	814
	905
Girth flange	741
	949
	789
	726

Step 4. Calculate the LMP for each condition based on T_{Di} with a duration of 100,000 hr using the guidance provided in API 579-1/ASME FFS-1, 2016 Edition, para. 10B.2.2. In terms of the variables used within this Appendix, the formula is as follows:

$$\text{LMP}(t_{100,000}, T_{Di})_i = \frac{(T_{Di} + 460) [C_{\text{LMP}} + \text{Log}_{10}(100,000)]}{1,000}$$

With a $C_{\text{LMP}} = 20.0$ per Table 10B.2 of API 579-1/ASME FFS-1, the LMP for each condition is shown in [Table A-3](#).

Step 5. Using the LMP determined in [Step 4](#), calculate an allowable duration, $(t_{\text{all}})_i$ for the actual temperature, T_i , of the operating condition using the guidance provided in API 579-1/ASME FFS-1, 2016 Edition, para. 10B.2.2 (see [Table A-4](#)).

$$(t_{\text{all}})_i = 10 \exp \left[\left(\frac{1,000 \cdot \text{LMP}_i}{T_i + 460} \right) - C_{\text{LMP}} \right]$$

Step 6. Compute the life fraction, λ_i , for each operating condition (see [Table A-5](#)):

$$\lambda_i = t_i / (t_{\text{all}})_i$$

Only the condition in the creep regime (i.e., Condition 2) requires evaluation. Any other conditions in the creep regime (if specified) would require similar evaluation by component stress.

Step 7. Determine if the design, considering all operating conditions in the creep regime, is acceptable if the following requirement is met:

$$\Delta = \sum \lambda_i \leq 0.8$$

For this example, the largest component sum, Δ , is 0.443, which is less than 0.8, so this design is considered acceptable. Note that the life fraction of each component is evaluated separately against the acceptance criterion.

**Table A-1
Stress Conditions**

Component	Stress Description	Code Stress, psi [Note (1)]	Calculated Stress Basis	Calculated Stress, σ_i , psi
Cylinder	Circumferential stress due to internal pressure	17,000	code stress	17,000
2:1 Ellipsoidal head	Circumferential stress due to internal pressure	16,150	code stress	16,150
Nozzles	Local membrane stress, P_L	19,476	code stress/1.25	15,581
Tubesheet	Bending stress, σ	35,171	code stress/1.67	21,060
	Shear stress, τ	10,601	code stress \times 1.25	13,251
Girth Flange	Longitudinal hub stress, S_H	19,245	code stress/1.25	15,396
	Radial flange stress, S_R	4,032	code stress	4,032
	Tangential flange stress, S_T	12,644	code stress	12,644
	Maximum of $(S_H + S_R)/2$ or $(S_H + S_T)/2$	15,945	code stress	15,945

NOTE: (1) Code stress is based on operating conditions of 1,700 psig at 800°F.

**Table A-2
Calculated Stress**

Condition No.	Component	Operating Temperature, T_b , °F	Calculated Stress, σ_b , psi	$\frac{2}{3} * S_y$, psi	$S_{UTS} / 3.5$, psi
2	Cylinder	800	17,000	17,000	18,371
	2:1 Ellipsoidal head		16,150	17,000	18,371
	Nozzles		15,581	17,000 [Note (1)]	18,371 [Note (1)]
	Tubesheet		21,060	21,667	21,429
			13,251		
			15,396		
	Girth flange		16,067	18,371	
			4,032		
12,644					
15,945					

NOTE: (1) The stress, P_L , calculated for opening reinforcement pertains to the cylinder, not the nozzle.

**Table A-3
LMP Values**

Condition No.	Component	Rupture Life, hr	C_{LMP}	T_{Div} , °F	LMP _i
2	Cylinder	100,000	20.0	717	29.43
	2:1 Ellipsoidal head		20.0	730	29.75
	Nozzles		20.0	738	29.95
	Tubesheet		20.0	814	31.85
			20.0	905	34.13
			20.0	741	30.03
			20.0	949	35.23
			20.0	789	31.23
	Girth flange		20.0	726	29.65

Table A-4
Allowable Duration Values

Condition No.	Component	T_b , °F	C_{LMP}	LMP_i	$(t_{all})_i$
2	Cylinder	800	20.0	29.43	2,255
	2:1 Ellipsoidal head		20.0	29.75	4,084
	Nozzles		20.0	29.95	5,886
	Tubesheet		20.0	31.85	189,574
			20.0	34.13	12,115,277
	Girth flange		20.0	30.03	6,751
			20.0	35.23	90,437,637
			20.0	31.23	60,499
20.0		29.65	3,402		

Table A-5
Life Fraction Values

Condition No.	Component	T_b , °F	P_b , psig	T_b , hr	$(t_{all})_i$	λ_i
2	Cylinder	800	1,700	1,000	2,255	0.443
	2:1 Ellipsoidal head				4,084	0.245
	Nozzles				5,886	0.170
	Tubesheet				189,574	0.005
					12,115,277	0.000
	Girth flange				6,751	0.148
					90,437,637	0.000
					60,499	0.017
3,402		0.294				

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Case 2953

Use of Alloy SUS315J1TP Pipe in Accordance With JIS G 3459:2016 in the Construction of Heating Boilers Per Part HF

Section IV

Approval Date: May 16, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may Alloy SUS315J1TP pipe meeting the material requirements of JIS G 3459:2016 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that Alloy SUS315J1TP pipe meeting the material requirements of JIS G 3459:2016 may be used in the construction of heating boilers under Section IV, Part HF, provided the following requirements are met:

- (a) The allowable stress values for seamless pipe with Alloy SUS315J1TP shall be as listed in [Table 1](#) and [Table 1M](#).
- (b) The minimum tensile strength shall be 75 ksi (520 MPa).
- (c) The minimum yield strength shall be 30 ksi (205 MPa).
- (d) Separate welding procedure qualifications conducted in accordance with Section IX shall be required for this material. For the purpose of welding and brazing procedures and performance qualifications, this material shall be considered P-No. 8, Group 1.

(e) For external pressure, Section II, Part D, Figure HA-1 shall be used.

(f) This material may utilize the minimum thickness exceptions of HF-301.1(c).

(g) Flattening tests shall be made on all pipe including seamless pipe.

(h) The minimum elongation values in [Table 2](#) shall apply to all pipe including pipe whose outside diameter is less than 1.574 in. (40 mm).

(i) The pipe shall be made by a seamless process, laser welding, electric resistance welding, or by an automatic welding process with no addition of filler metal in the welding operation.

(j) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of JIS G 3459:2016, Table 2 shall apply.

(k) The materials manufacturer or vendor shall submit inspection documents (Reference JIS G 3459:2016, clauses 15 and 17) to the purchaser with a statement that the pipe has been manufactured, inspected, and tested in accordance with the requirements of the JIS Specification and this Case.

(l) The materials manufacturer or vendor shall identify the material being provided. The identification shall be traceable to the inspection documents.

(m) All other requirements of Section IV shall be met.

(n) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
Up to 100	15.0
150	15.0
200	15.0
250	14.8
300	14.6
350	14.5
400	14.3
450	13.8
500	13.3

GENERAL NOTES:

- (a) The maximum thickness of the material covered by this table is $\frac{3}{8}$ in.
- (b) For welded pipe, the stress values listed in this table shall be multiplied by a weld joint factor of 0.85.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
Up to 40	103.4
65	103.3
100	103.2
125	101.8
150	100.4
175	99.8
200	98.7
225	96.0
250	92.7
275 [Note (1)]	90.7

GENERAL NOTES:

- (a) The maximum thickness of the material covered by this table is 10.0 mm.
- (b) For welded pipe, the stress values listed in this table shall be multiplied by a weld joint factor of 0.85.

NOTE: (1) The maximum allowable use temperature is 260°C. The value for 275°C is provided for interpolation only.

Table 2
Minimum Elongation, %, for Alloy SUS315J1TP Pipe With Wall Thickness Under 0.315 in. (8 mm)

Test Piece Per JIS Z 2241	Wall Thickness, in. (mm)								
	0.315 in. (8 mm) and Over	>0.276 in. (>7 mm) to <0.315 in. (<8 mm)	>0.236 in. (>6 mm) to 0.276 in. (7 mm)	>0.197 in. (>5 mm) to 0.236 in. (6 mm)	>0.157 in. (>4 mm) to 0.197 in. (5 mm)	>0.118 in. (>3 mm) to 0.157 in. (4 mm)	>0.078 in. (>2 mm) to 0.118 in. (3 mm)	>0.039 in. (>1 mm) to 0.078 in. (2 mm)	0.039 in. (1 mm) and Under
No. 12 Parallel to axis (strip-form)	35%	35%	34%	32%	30%	29%	28%	26%	24%
No. 5 Perpendicular to axis (flat-form)	25%	25%	24%	22%	20%	19%	18%	16%	14%

Case 2956

Alternative Flaw Evaluation and Acceptance Criteria for Subsurface Flaw Near Component Surface

Section VIII, Division 3

Approval Date: March 13, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what requirements may alternative flaw evaluation and acceptance criteria for subsurface flaw near component surface be used instead of Section VIII, Division 3, KE-301?

Reply: It is the opinion of the Committee that alternative flaw evaluation and acceptance criteria for subsurface flaw near component surface may be used instead of Section VIII, Division 3, KE-301, provided the following requirements are met:

(a) If approved by the User, alternative flaw evaluation and acceptance criteria for subsurface flaw near component surface in accordance with this Case may be used.

(b) The use of this Case is limited to weld thickness equal to or more than 4 in. (100 mm).

(c) The use of this Case is limited to materials shown in Table 1.

(d) When $S \leq 0.4d$ as shown in Figure 1, a subsurface flaw near component surface shall be classified as a surface flaw.

(e) When the requirements of Section VIII, Division 3, KE-301 are met, subsurface flaws with $0.4 < Y_a \leq 1.0$ shall be evaluated using the acceptance criteria in Table 2 [or Figure 2, sketch (a)] or Table 3 [or Figure 2, sketch (b)] instead of Section VIII, Division 3, Table KE-301-1 or Table KE-301-2.

(f) The subsurface flaws with $Y_a > 1.0$ and surface flaws shall be evaluated using the acceptance criteria of Section VIII, Division 3, Table KE-301-1 or Table KE-301-2.

(g) Unacceptable flaws shall be repaired, and the rewelded joints and the repaired areas shall be reexamined in accordance with KF-240.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Acceptable Materials

Material Specification	Type/Grade/Class	UNS Number	Nominal Composition	Product Form
SA-516	60	K02100	Carbon steel	Plate
SA-516	65	K02403	Carbon steel	Plate
SA-350	LF2	K03011	Carbon steel	Forgings
SA-105	...	K03504	Carbon steel	Forgings
SA-516	70	K02700	Carbon steel	Plate
SA-765	IV	K02009	Carbon steel	Forgings
SA-738	B	K12001	Carbon steel	Plate
SA-336	F22	K21590	2 $\frac{1}{4}$ Cr-1Mo	Forgings
SA-387	22	K21590	2 $\frac{1}{4}$ Cr-1Mo	Plate
SA-508	22	K21590	2 $\frac{1}{4}$ Cr-1Mo	Forgings
SA-336	F22V	K31835	2 $\frac{1}{4}$ Cr-1Mo-V	Forgings
SA-182	F22V	K31835	2 $\frac{1}{4}$ Cr-1Mo-V	Forgings
SA-541	22V	K31835	2 $\frac{1}{4}$ Cr-1Mo-V	Forgings
SA-542	D	K31835	2 $\frac{1}{4}$ Cr-1Mo-V	Plate
SA-832	22V	K31835	2 $\frac{1}{4}$ Cr-1Mo-V	Plate
SA-336	F3V	K31830	3Cr-1Mo- $\frac{1}{4}$ V-Ti-B	Forgings
SA-832	21V	K31830	3Cr-1Mo- $\frac{1}{4}$ V-Ti-B	Plate

Table 2
Alternative Subsurface Flaw Acceptance Criteria for 4 in. to 12 in. (100 mm to 300 mm) Thick Weld and With Y_a Greater Than 0.4 and Less Than or Equal to 1.0

Flaw Aspect Ratio, a/ℓ	Subsurface Flaw, a/t [Note (1)]
0.00	$0.020Y_a^{1.00}$
0.05	$0.022Y_a^{0.90}$
0.10	$0.025Y_a^{0.69}$
0.15	$0.029Y_a^{0.47}$
0.20	$0.033Y_a^{0.47}$
0.25	$0.038Y_a^{0.61}$
0.30	$0.044Y_a^{0.77}$
0.35	$0.051Y_a^{0.93}$
0.40	$0.058Y_a^{1.00}$
0.45	$0.067Y_a^{1.00}$
0.50	$0.076Y_a^{1.00}$

GENERAL NOTES:

- (a) Use with Figure 1; see Figure 2, sketch (a).
- (b) For intermediate flaw aspect ratio a/ℓ , linear interpolation is permissible.
- (c) t is thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thickness at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet weld shall be included in t .
- (d) $Y_a = S/d$, where Y_a is the flaw-to-surface proximity factor. S is the distance of the indication from the nearest surface of the component (see Figure 1). If a subsurface flaw with $0.4 < S/a \leq 1.0$ is alternatively classified as a subsurface flaw as shown in Figure 1, the acceptance criteria of this Table [or Figure 2, sketch (a)] shall be used.
- (e) If the acceptance criteria in this table results in a flaw length, ℓ , less than 0.25 in. (6.4 mm), a value of 0.25 in. (6.4 mm) may be used.

NOTE: (1) 4 in. (100 mm) $\leq t \leq$ 12 in. (300 mm)

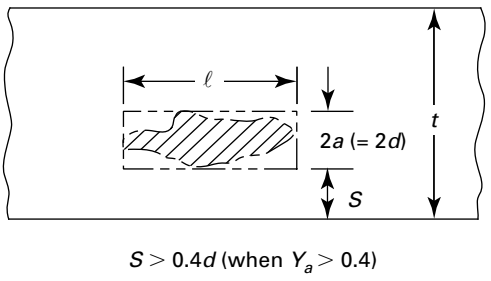
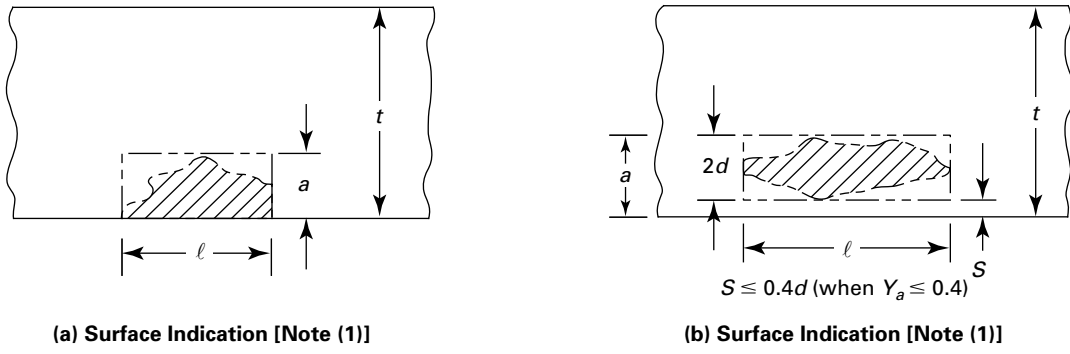
Table 3
Alternative Subsurface Flaw Acceptance Criteria for 16 in. (400 mm) Thick Weld and With Y_a Greater Than 0.4 and Less Than or Equal to 1.0

Flaw Aspect Ratio, a/ℓ	Subsurface Flaw, a/t
0.00	$0.015Y_a^{1.00}$
0.05	$0.017Y_a^{0.91}$
0.10	$0.019Y_a^{0.69}$
0.15	$0.021Y_a^{0.43}$
0.20	$0.025Y_a^{0.45}$
0.25	$0.028Y_a^{0.57}$
0.30	$0.033Y_a^{0.75}$
0.35	$0.038Y_a^{0.90}$
0.40	$0.043Y_a^{1.00}$
0.45	$0.049Y_a^{1.00}$
0.50	$0.056Y_a^{1.00}$

GENERAL NOTES:

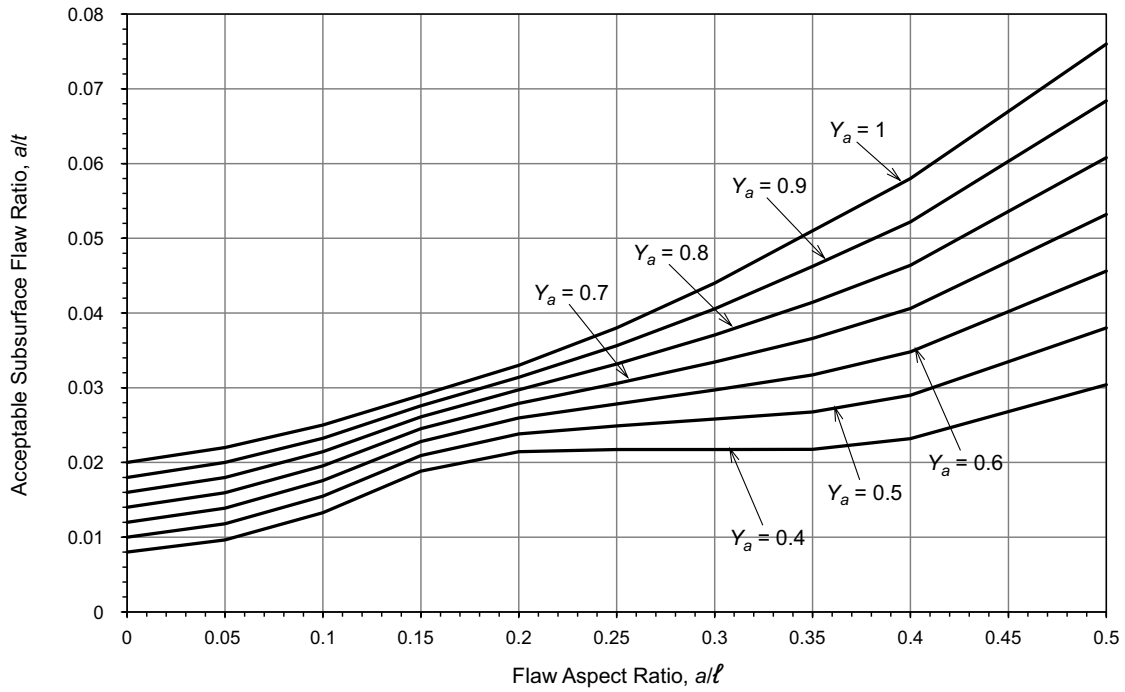
- (a) Use with [Figure 1](#); see [Figure 2](#), sketch (b).
- (b) For intermediate flaw aspect ratio a/ℓ , linear interpolation is permissible.
- (c) t is thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thickness at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet weld shall be included in t .
- (d) $Y_a = S/d$, where Y_a is the flaw-to-surface proximity factor. S is the distance of the indication from the nearest surface of the component (see [Figure 1](#)). If a subsurface flaw with $0.4 < S/a \leq 1.0$ is alternatively classified as a subsurface flaw as shown in [Figure 1](#), the acceptance criteria of this Table [or [Figure 2](#), sketch (b)] shall be used.
- (e) If a thickness is larger than 16 in. (400 mm), flaw acceptance values for a thickness of 16 in. (400 mm) shall be used.
- (f) When the thickness is larger than 12 in. (300 mm) and less than 16 in. (400 mm), linear interpolation between values for 12 in. (300 mm) in [Table 1](#) and those for 16 in. (400 mm) in [Table 2](#) is permissible.

Figure 1
Alternative Flaw Classification of Single Indication

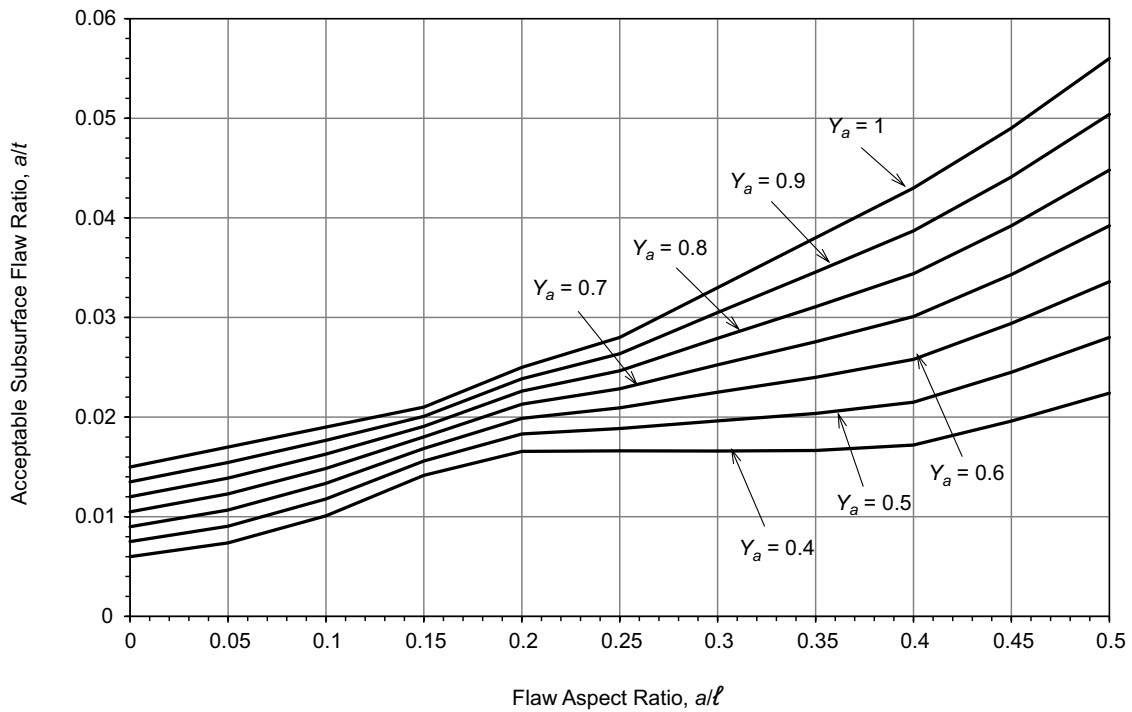


NOTE: (1) $Y_a = S/d$, where Y_a is the flaw-to-surface proximity factor.

Figure 2
Alternative Subsurface Flaw Acceptance Criteria



(a) For weld thickness 4 in. (100 mm) $\leq t \leq$ 12 in. (300 mm) [Note (1)]



(b) For weld thickness $t = 16$ in. (400 mm) [Note (2)]

NOTES:

- (1) This graph is obtained from acceptance criteria for subsurface flaw for 4 in. (100 mm) $\leq t \leq$ 12 in. (300 mm) in [Table 2](#).
- (2) This graph is obtained from acceptance criteria for subsurface flaw for $t = 16$ in. (400 mm) in [Table 3](#).

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Case 2957

Use of Backing in Helical Butt-Welded Joints Under External Pressure

Section I

Approval Date: April 12, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may backing used on a helical butt-welded joint under external pressure remain in place?

Reply: It is the opinion of the Committee that backing used on a helical butt-welded joint under external pressure may remain in place provided that all of the following requirements are met:

(a) The helical weld shall be substantially circumferential, where the weld shall not be greater than 13 deg from the circumferential axis of the cylindrical shell.

(b) The maximum allowable working external pressure of the cylindrical shell shall not exceed 300 psig (2 MPa) and the design temperature shall not exceed 600°F (315°C). The shell shall not be subjected to internal pressure.

(c) The weld is not subject to radiant heat.

(d) The backing material shall not be in contact with steam or water and shall be non-loadbearing.

(e) The pressure part to be welded shall be a P-No. 1 material.

(f) The weld shall be limited to components under external pressure, fully contained within another shell.

(g) The requirements of PW-41.2.4 shall apply.

(h) The weld shall be made using the GMAW, GTAW, SAW, FCAW, or SMAW process.

(i) Volumetric examination of the entire length of the weld in accordance with PW-11 shall be performed. If ultrasonic examination is used, it shall be in accordance with Code Case 2235 or Code Case 2816, depending on the thickness of the material.

(j) If ultrasonic volumetric examination is used, the procedure and a calibration block shall be created specifically for the weld geometry inclusive of backing. If either Code Case 2235 or Code Case 2816 is used, the examination demonstration standard shall be representative of the weld type, i.e., helical with a backing.

(k) The helically welded shell shall have a length not exceeding 120 in. (3048 mm), an outside diameter not exceeding 72 in. (1829 mm), and a thickness not exceeding 1 in. (25 mm).

(l) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2958

Alternative Flaw Evaluation and Acceptance Criteria for Subsurface Flaw Near Component Surface for Class 1 and Class 2

Section VIII, Division 2

Approval Date: July 2, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what requirements may alternative flaw evaluation and acceptance criteria for subsurface flaw near component surface be used instead of Section VIII, Division 2, 7.5.5?

Reply: It is the opinion of the Committee that alternative flaw evaluation and acceptance criteria for subsurface flaw near component surface may be used instead of Section VIII, Division 2, 7.5.5, provided the following requirements are met:

(a) If approved by the User, alternative flaw evaluation and acceptance criteria for subsurface flaw near component surface in accordance with this Case may be used.

(b) The use of this Case is limited to weld thickness equal to or more than 100 mm (4 in.).

(c) The use of this Case is limited to materials shown in Table 1.

(d) When $S \leq 0.4d$ as shown in Figure 1, a subsurface flaw near component surface shall be classified as a surface flaw.

(e) When the requirements of Section VIII, Division 2, 7.5.5.3(a) through 7.5.5.3(e) are met, subsurface flaws with $0.4 < Y_a \leq 1.0$ shall be evaluated using the acceptance criteria in Table 2 [or Figure 2, sketch (a)] or Table 3 [or Figure 2, sketch (b)] instead of Section VIII, Division 2, Table 7.10 or Table 7.11.

(f) The subsurface flaws with $Y_a > 1.0$ and surface flaws shall be evaluated using the acceptance criteria of Section VIII, Division 2, Table 7.8, 7.9, 7.10, or 7.11.

(g) Unacceptable flaws shall be repaired, and the rewelded joints and the repaired areas shall be reexamined in accordance with 7.5.9(b)(3).

(h) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Acceptable Materials

Material Specification	Type/Grade/Class	UNS Number	Nominal Composition	Product Form
SA-105	...	K03504	Carbon steel	Forgings
SA-182	F1	K12822	C- $\frac{1}{2}$ Mo	Forgings
	F2	K12122	$\frac{1}{2}$ Cr- $\frac{1}{2}$ Mo	Forgings
	F3V	K31830	3Cr-1Mo- $\frac{1}{4}$ V-Ti-B	Forgings
	F3VCb	K31390	3Cr-1Mo- $\frac{1}{4}$ V-Cb-Ca	Forgings
	F5	K41545	5Cr- $\frac{1}{2}$ Mo	Forgings
	F5a	K42544	5Cr- $\frac{1}{2}$ Mo	Forgings
	F9	K90941	9Cr-1Mo	Forgings
	F12, Cl 1	K11562	1Cr- $\frac{1}{2}$ Mo	Forgings
	F12, Cl. 2	K11564	1Cr- $\frac{1}{2}$ Mo	Forgings
	F11, Cl. 1	K11597	1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo-Si	Forgings
	F11, Cl. 2	K11572	1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo-Si	Forgings
	F21	K31545	3Cr-1Mo	Forgings
	F22, Cl. 1	K21590	2 $\frac{1}{4}$ Cr-1Mo	Forgings
	F22, Cl. 3	K21590	2 $\frac{1}{4}$ Cr-1Mo	Forgings
	F22V	K31835	2 $\frac{1}{4}$ Cr-1Mo- $\frac{1}{4}$ V	Forgings
	F91	K90901	9Cr-1Mo-V	Forgings
	FR	K22035	2Ni-1Cu	Forgings
SA-266	1	K03506	Carbon steel	Forgings
	2	K03506	Carbon steel	Forgings
	3	K05001	Carbon steel	Forgings
	4	K03017	Carbon steel	Forgings
SA-335	P1	K11522	C- $\frac{1}{2}$ Mo	Seamless pipe
	P2	K11547	$\frac{1}{2}$ Cr- $\frac{1}{2}$ Mo	Seamless pipe
	P5	K41545	5Cr- $\frac{1}{2}$ Mo	Seamless pipe
	P5b	K51545	5Cr- $\frac{1}{2}$ Mo-Si	Seamless pipe
	P5c	K41245	5Cr- $\frac{1}{2}$ Mo-Ti	Seamless pipe
	P9	K90941	9Cr-1Mo	Seamless pipe
	P11	K11597	1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo-Si	Seamless pipe
	P12	K11562	1Cr- $\frac{1}{2}$ Mo	Seamless pipe
	P21	K31545	3Cr-1Mo	Seamless pipe
	P22	K21590	2 $\frac{1}{4}$ Cr-1Mo	Seamless pipe
	P91	K90901	9Cr-1Mo-V	Seamless pipe
SA-336	F1	K11564	1Cr- $\frac{1}{2}$ Mo	Forgings
	F3V	K31830	3Cr-1Mo- $\frac{1}{4}$ V-Ti-B	Forgings
	F3VCb	K31390	3Cr-1Mo- $\frac{1}{4}$ V-Cb-Ca	Forgings
	F5	K41545	5Cr-1Mo	Forgings
	F5A	K42544	5Cr-1Mo	Forgings
	F9	K90941	9Cr-1Mo	Forgings
	F11, Cl. 2	K11572	1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo-Si	Forgings
	F11, Cl. 3	K11572	1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo-Si	Forgings
	F12	K11564	1Cr- $\frac{1}{2}$ Mo	Forgings
	F21, Cl. 1	K31545	3Cr-1Mo	Forgings
	F21, Cl. 3	K31545	3Cr-1Mo	Forgings

Table 1
Acceptable Materials (Cont'd)

Material Specification	Type/Grade/Class	UNS Number	Nominal Composition	Product Form
	F22, Cl. 1	K21590	2¼Cr-1Mo	Forgings
	F22, Cl. 3	K21590	2¼Cr-1Mo	Forgings
	F22V	K31835	2¼Cr-1Mo-¼V	Forgings
	F91 [Note (1)]	K90901	9Cr-1Mo-V	Forgings
SA-350	LF1	K03009	Carbon steel	Forgings
	LF2	K03011	Carbon steel	Forgings
SA-387	2, Cl. 1	K12143	½Cr-½Mo	Plate
	2, Cl. 2	K12143	½Cr-½Mo	Plate
	5, Cl. 1	K41545	5Cr-½Mo	Plate
	5, Cl. 2	K41545	5Cr-½Mo	Plate
	11, Cl. 1	K11789	1¼Cr-½Mo-Si	Plate
	11, Cl. 2	K11789	1¼Cr-½Mo-Si	Plate
	12, Cl. 1	K11757	1Cr-½Mo	Plate
	12, Cl. 2	K11757	1Cr-½Mo	Plate
	21, Cl. 1	K31545	3Cr-1Mo	Plate
	21, Cl. 2	K31545	3Cr-1Mo	Plate
	22, Cl. 1	K21590	2¼Cr-1Mo	Plate
	22, Cl. 2	K21590	2¼Cr-1Mo	Plate
	91, Cl. 2	K90901	9Cr-1Mo-V	Plate
SA-508	3V	K31830	3Cr-1Mo-¼V-Ti-B	Forgings
	3VCb	K31390	3Cr-1Mo-¼V-Cb-Ca	Forgings
SA-516	55	K01800	Carbon steel	Plate
	60	K02100	Carbon steel	Plate
	65	K02403	Carbon steel	Plate
	70	K02700	Carbon steel	Plate
SA-541	3V	K31830	3Cr-1Mo-¼V-Ti-B	Forgings
	3VCb	K31390	3Cr-1Mo-¼V-Cb-Ca	Forgings
	22, Cl. 3	K21390	2¼Cr-1Mo	Forgings
	22V	K31835	2¼Cr-1Mo-¼V	Forgings
SA-542	B, Cl. 4	...	2¼Cr-1Mo	Plate
	C, Cl. 4a	...	3Cr-1Mo-¼V-Ti-B	Plate
	E, Cl. 4a	K31390	3Cr-1Mo-¼V-Cb-Ca	Plate
	D, Cl. 4a	...	2¼Cr-1Mo-¼V	Plate
SA-738	A	K12447	Carbon steel	Plate
	B	K12007	Carbon steel	Plate
	C	...	Carbon steel	Plate
SA-832	21V	K31830	3Cr-1Mo-¼V-Ti-B	Plate
	23V	K31390	3Cr-1Mo-¼V-Cb-Ca	Plate
	22V	K31835	2¼Cr-1Mo-V	Plate

NOTE: (1) This row applies to Class 2 construction only.

Table 2
Alternative Subsurface Flaw Acceptance Criteria for
Welds With Thickness Between 100 mm to 300 mm (4 in.
to 12 in.) and With $0.4 < Y_a \leq 1.0$

Flaw Aspect Ratio, a/ℓ	Subsurface Flaw, a/t [Note (1)]
0.00	$0.020Y_a^{1.00}$
0.05	$0.022Y_a^{0.90}$
0.10	$0.025Y_a^{0.69}$
0.15	$0.029Y_a^{0.47}$
0.20	$0.033Y_a^{0.47}$
0.25	$0.038Y_a^{0.61}$
0.30	$0.044Y_a^{0.77}$
0.35	$0.051Y_a^{0.93}$
0.40	$0.058Y_a^{1.00}$
0.45	$0.067Y_a^{1.00}$
0.50	$0.076Y_a^{1.00}$

GENERAL NOTES:

- Use with Figure 1; see Figure 2, sketch (a).
- The parameter t is thickness of the weld excluding any allowable reinforcement, and the parameter ℓ is the length of the flaw. For a butt weld joining two members having different thickness at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet weld shall be included in t .
- $Y_a = S/d$, where Y_a is the flaw-to-surface proximity factor. S is the distance of the indication from the nearest surface of the component (see Figure 1). If a subsurface flaw with $0.4 < S/d \leq 1.0$ is alternatively classified as a subsurface flaw as shown in Figure 1, the acceptance criteria of this Table [or Figure 2, sketch (a) or sketch (b)] shall be used.
- Linear interpolation is permissible for intermediate values of the flaw aspect ratio a/ℓ .
- If the acceptance criteria in this Table results in a flaw length, ℓ , less than 6.4 mm (0.25 in.), a value of 6.4 mm (0.25 in.) may be used.

NOTE: (1) $100 \text{ mm (4 in.)} \leq t \leq 300 \text{ mm (12 in.)}$

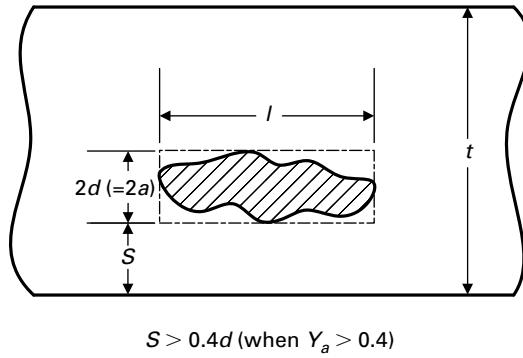
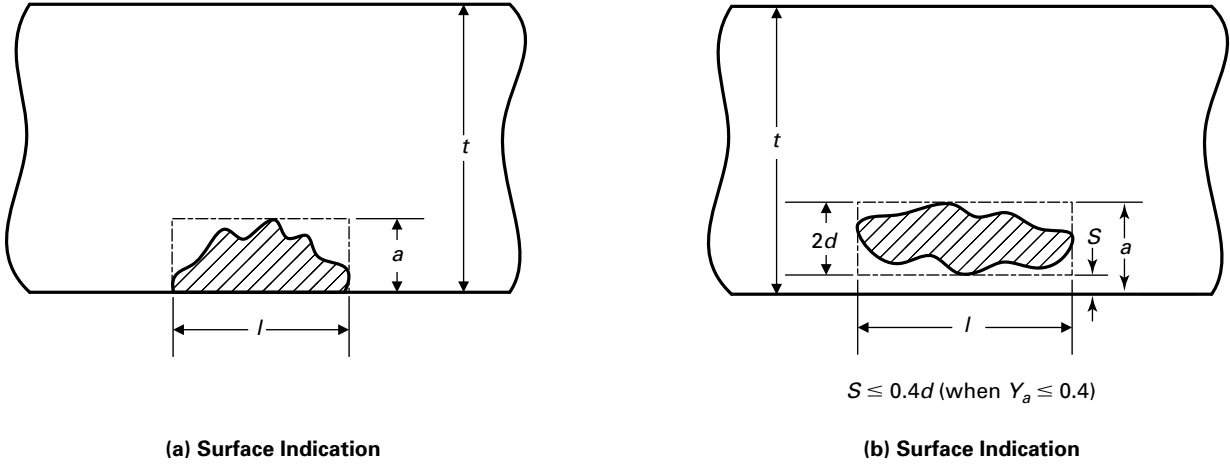
Table 3
Alternative Subsurface Flaw Acceptance Criteria for
Welds With Thickness of 400 mm (16 in.) and With
 $0.4 < Y_a \leq 1.0$

Flaw Aspect Ratio, a/ℓ	Subsurface Flaw, a/t
0.00	$0.015Y_a^{1.00}$
0.05	$0.017Y_a^{0.91}$
0.10	$0.019Y_a^{0.69}$
0.15	$0.021Y_a^{0.43}$
0.20	$0.025Y_a^{0.45}$
0.25	$0.028Y_a^{0.57}$
0.30	$0.033Y_a^{0.75}$
0.35	$0.038Y_a^{0.90}$
0.40	$0.043Y_a^{1.00}$
0.45	$0.049Y_a^{1.00}$
0.50	$0.056Y_a^{1.00}$

GENERAL NOTES:

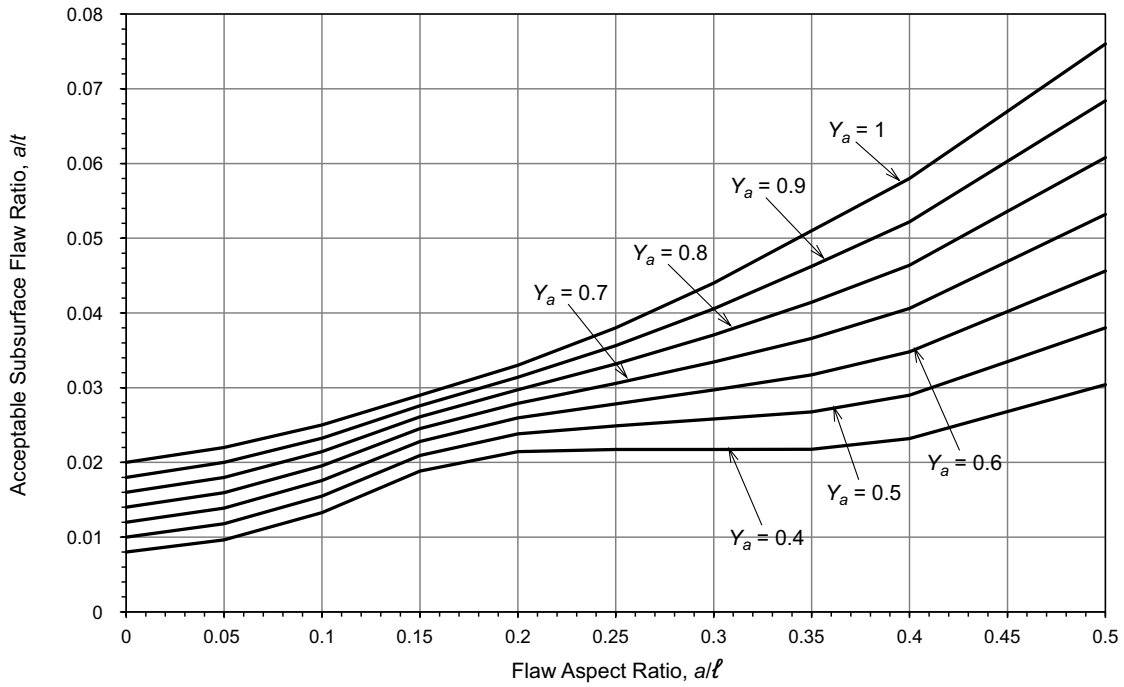
- Use with Figure 1; see Figure 2, sketch (b).
- The parameter t is thickness of the weld excluding any allowable reinforcement, and the parameter ℓ is the length of the flaw. For a butt weld joining two members having different thickness at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet weld shall be included in t .
- $Y_a = S/d$, where Y_a is the flaw-to-surface proximity factor. S is the distance of the indication from the nearest surface of the component (see Figure 1). If a subsurface flaw with $0.4 < S/d \leq 1.0$ is alternatively classified as a subsurface flaw as shown in Figure 1, the acceptance criteria of this Table [or Figure 2, sketch (b)] shall be used.
- Linear interpolation is permissible for intermediate values of the flaw aspect ratio a/ℓ .
- When the weld thickness, $t \geq 400 \text{ mm (16 in.)}$, the acceptance criteria for a thickness of 400 mm (16 in.) shall be applied.
- When $300 \text{ mm (12 in.)} \leq \text{weld thickness, } t < 400 \text{ mm (16 in.)}$, linear interpolation between the acceptance criteria for 300 mm (12 in.) in Table 1 and those for 400 mm (16 in.) in Table 2 is permitted.

Figure 1
Alternative Flaw Classification of Single Indication

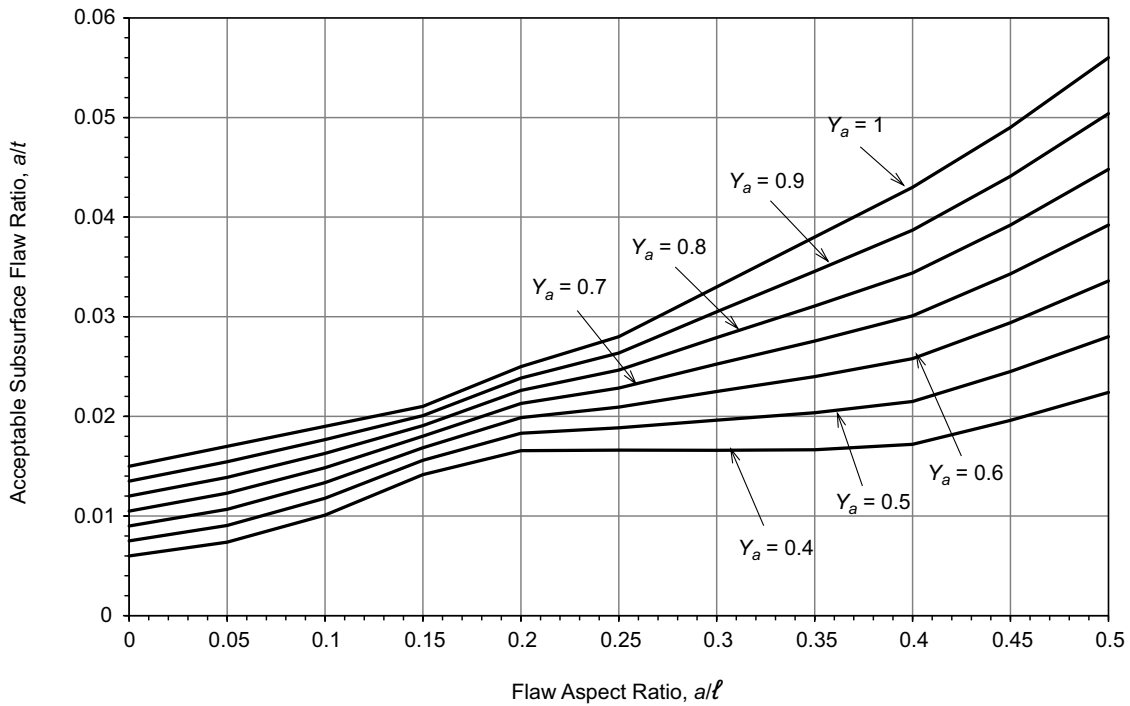


GENERAL NOTE: $Y_a = S/d$, where Y_a is the flaw-to-surface proximity factor.

Figure 2
Alternative Subsurface Flaw Acceptance Criteria



(a) For weld thickness $100 \text{ mm} (4 \text{ in.}) \leq t \leq 300 \text{ mm} (12 \text{ in.})$ [Note (1)]



(b) For weld thickness $t = 400 \text{ mm} (16 \text{ in.})$ [Note (2)]

NOTES:

- (1) This graph is obtained from acceptance criteria for subsurface flaw for $100 \text{ mm} (4 \text{ in.}) \leq t \leq 300 \text{ mm} (12 \text{ in.})$ in [Table 2](#).
- (2) This graph is obtained from acceptance criteria for subsurface flaw for $t = 400 \text{ mm} (16 \text{ in.})$ in [Table 3](#).

Case 2959-1
Laser Annealing of Nameplates

(25)

Section VIII, Division 1

ANNULLED

March 30, 2025

Reason: No longer needed.

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Case 2960

Use of Alloy SUS315J1TB Tube in Accordance With JIS G 3463:2012 in the Construction of Heating Boilers Per Part HF

Section IV

Approval Date: June 19, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may Alloy SUS315J1TB tube meeting the material requirements of JIS G 3463:2012 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that Alloy SUS315J1TB tube meeting the material requirements of JIS G 3463:2012 may be used in the construction of heating boilers under Section IV, Part HF, provided the following requirements are met:

(a) The allowable stress values for seamless tube with Alloy SUS315J1TB shall be as listed in [Table 1](#) and [Table 1M](#).

(b) The minimum tensile strength shall be 75 ksi (520 MPa).

(c) The minimum yield strength shall be 30 ksi (205 MPa).

(d) Separate welding procedure qualifications conducted in accordance with Section IX shall be required for this material. For the purpose of welding and brazing procedures and performance qualifications, this material shall be considered P-No. 8, Group 1.

(e) For external pressure, Section II, Part D, Figure HA-1 shall be used.

(f) Minimum wall thickness of tube shall be not less than 0.020 in. (0.5 mm), and the outside diameter shall not exceed 0.98 in. (24.9 mm).

(g) Flattening or flaring tests shall be made on all tube including seamless tube.

(h) Welded tube shall be tested in accordance with the requirements and methods for reverse flattening tests.

(i) The tube shall be made by a seamless process, laser welding, electric resistance welding, or by an automatic welding process with no addition of filler metal in the welding operation.

(j) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of JIS G 3463:2012, Table 2 shall apply.

(k) The minimum elongation values in [Table 2](#) and [Table 3](#) shall apply.

(l) The materials Manufacturer or vendor shall submit an inspection certificate (Reference JIS G 3463:2012, clauses 12 and 14) to the purchaser with a statement that the tube has been manufactured, inspected, and tested in accordance with the requirements of the JIS Specification and this Case.

(m) The materials Manufacturer or vendor shall identify the material being provided. The identification shall be traceable to the inspection certificate.

(n) All other requirements of Section IV shall be met.

(o) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
Up to 100	15.0
150	15.0
200	15.0
250	14.8
300	14.6
350	14.5
400	14.3
450	13.8
500	13.3

GENERAL NOTES:

- (a) The maximum thickness of the material covered by this Table is $\frac{3}{8}$ in.
- (b) For welded tube, the stress values listed in this Table shall be multiplied by a weld joint factor of 0.85.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
Up to 40	103.4
65	103.3
100	103.2
125	101.8
150	100.4
175	99.8
200	98.7
225	96.0
250	92.7
275 [Note (1)]	90.7

GENERAL NOTES:

- (a) The maximum thickness of the material covered by this Table is 10.0 mm.
- (b) For welded tube, the stress values listed in this Table shall be multiplied by a weld joint factor of 0.85.

NOTE: (1) The maximum allowable use temperature is 260°C. The value for 275°C is provided for interpolation only.

Table 2
Minimum Elongation, %, for Alloy SUS315J1TB Tube Based on Outside Diameter

Test Piece Per JIS Z 2241	Outside Diameter, in. (mm)		
	Less Than 0.394 in. (10 mm)	0.394 in. (10 mm) or Over to Less Than 0.787 in. (20 mm)	0.787 in. (20 mm) or Over
No. 11 Tube form	27%	30%	35%
No. 12 Strip form	...	...	35%

Table 3
Minimum Elongation, %, for Alloy SUS315J1TB Tube With Wall Thickness With Less Than 0.315 in. (8 mm)

Test Piece Per JIS Z 2241	Wall Thickness, in. (mm)					
	Up to 0.039 in. (1 mm)	>0.039 in. (>1 mm) Up to 0.079 in. (2 mm)	>0.079 in. (>2 mm) Up to 0.118 in. (3 mm)	>0.118 in. (>3 mm) up to 0.157 in. (4 mm)	>0.157 in. (>4 mm) Up to 0.197 in. (5 mm)	>0.197 in. (>5 mm) Up to 0.236 in. (6 mm)
No. 12 Parallel to axis	25%	26%	28%	29%	30%	32%

GENERAL NOTE: When the tensile test is carried out using No. 12 test pieces from tubes with wall thicknesses less than 0.315 in. (8 mm), the minimum elongation values in this Table shall apply.

Case 2961

Use of Stud Welding for Fitting Attachment of Part HLW Water Heaters and Storage Heaters

Section IV

Approval Date: June 19, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may arc-stud welding and resistance-stud welding, as defined in Nonmandatory Appendix E, E-101, where the pressure exerts a tensile load on the studs, be used for the mechanical attachment of fittings used to secure piping to the front plate of a potable water heater?

Reply: It is the opinion of the Committee that arc-stud welding and resistance-stud welding, as defined in Nonmandatory Appendix E, E-101, where the pressure exerts a tensile load on the studs, may be used for the mechanical attachment of fittings used to secure piping to the front plate of a potable water heater, provided the following requirements are met:

(a) Mechanically attached internally or externally threaded fittings shall be limited to a maximum NPS 3 (DN 80) and shall be secured by a minimum of four studs.

(b) Daily production weld tests shall be as per HLW-460.5.

(c) Studs attached by stud welding shall not be in direct contact with product of combustion or flue gases.

(d) The minimum stud size used shall be not less than $\frac{1}{4}$ in. (6 mm) nominal diameter, and the maximum size shall not exceed $\frac{7}{8}$ in. (22 mm) nominal diameter.

(e) The type of the stud shall be limited to round internally or externally threaded studs.

(f) Base metal shall be of ferrous material specification as permitted by Section IV, and the base metal must be thick enough to prevent burn through.

(g) Stud material for arc-stud welding and resistance-stud welding of carbon steel shall be low carbon steel of an acceptable material in Section IV and with a carbon maximum of 0.27% and with a minimum tensile strength of 60,000 psi (400 MPa).

(h) The maximum spacing of studs shall not exceed 12 times the nominal diameter of the stud.

(i) Gaskets for internally or externally threaded fittings mechanically attached using arc-stud welding or resistance-stud welding may be of the flat or ring type, made of a material suitable for service at a minimum of 210°F (99°C). When ring-type gaskets are employed, a suitable recess shall be provided in the fitting to accommodate the gasket.

(j) The maximum allowable working pressure for a vessel with internally or externally threaded fittings mechanically attached using arc-welded or resistance-welded stud shall be established by proof test in accordance with HLW-500. Each size of the proposed connection shall be tested including the gasket method, studs, and internally or externally threaded fittings.

(k) Welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(l) All other requirements of Section IV shall be met.

(m) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2963

Alternative Rules for Design Temperature of Plain Furnaces

Section IV

Approval Date: July 30, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For Section IV construction, what alternatives to the design temperature stipulated in HG-312.1(b) can be used for the design of plain furnaces?

Reply: It is the opinion of the Committee that for Section IV construction, a design temperature not less than the mean expected wall temperature may be used as an alternative to the requirements of HG-312.1(b). This Case number shall be recorded on the Manufacturer's Data Report. All other applicable Section IV requirements shall be met.

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Case 2964

Allowable Compressive Stress in the Time-Dependent Regime

Section VIII, Division 1

Approval Date: July 2, 2019*

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May components operating in the time-dependent regime be designed for allowable compressive stress in Section VIII, Division 1 using the procedures outlined in this Case?

Reply: It is the opinion of the Committee that components operating in the time-dependent regime may be designed for allowable compressive stress in Section VIII, Division 1 using the procedures outlined in this Case.

1 NOMENCLATURE

- A = strain factor
- A_i = material constant where i varies between 0 and 4
- a = cross sectional area of a cylinder
 $= (\pi)(R_o^2 - R_i^2) \approx 2\pi Rt$
- B = allowable compressive stress
- B_i = material constant where i varies between 0 and 4
- D_F = design factor
- D_o = outside diameter
- Δ_{Ω}^{sr} = material scatter factor; set to 0.0 in this Case
- Δ_{Ω}^{cd} = material ductility factor; set to 0.0 in this Case
- E = modulus of elasticity
- E_t = tangent modulus
- ϵ_c = creep strain
- ϵ_e = elastic strain
- ϵ_{es} = engineering strain
- ϵ_p = plastic strain
- ϵ_t = total strain
- ϵ_{ys} = strain corresponding to yield stress
- Γ = effective length factor for column buckling
 $= 1.0$ for column pinned at both ends
 $= 0.5$ for column fixed at both ends
 $= 0.7$ for column pinned at one end and fixed at the other
- I = moment of inertia of the cylinder cross section =
 $(\pi/4)(R_o^4 - R_i^4) \approx \pi R^3 t$

- L = length of shell or column
- R = average radius
- R_i = inside radius
- R_o = outside radius
- r = radius of gyration
 $= (I/a)^{0.5} \approx R_o/\sqrt{2}$
- S_c = compressive stress obtained from Mandatory [Appendix I](#) of this Case
- σ = stress
- σ_c = allowable compressive stress in a column
- σ_{es} = engineering stress
- T = time
- T_e = temperature
- T_r = reference temperature; equal to 460°F and 273°C for calculations
- t = thickness

2 AXIAL COMPRESSION IN CYLINDERS

The allowable compressive stress in long cylindrical shells is obtained as follows:

Step 1. For any given temperature, assume a thickness t , an outside radius R_o , and operating time, T .

Step 2. Calculate factor A from the following equation:

$$A = 0.125/(R_o/t) \quad (1)$$

Step 3. Calculate compressive stress S_c at a given temperature from any of the methods given in Mandatory [Appendix I](#) of this Case for two time periods. The first time period is at hot tensile (HT is equal to or less than 1 hr) and the second is at the operating time period specified.

Step 4. Determine design factor D_F as follows:

(a) $T \leq 1.0$ hr

$$D_F = 2.0 \quad (2)$$

(b) $1 < T \leq 100,000$ hr

$$D_F = \frac{2}{1 + 0.0288 \ln(T)} \quad (3)$$

(c) $T > 100,000$ hr

$$D_F = 1.5 \quad (4)$$

* Corrected by errata, ASME BPVC.CC.BPV.S5-2019, July 2020.

Step 5. For each of the two time periods in [Step 3](#), calculate the allowable compressive stress B given by [eqs. \(5\)](#) and [\(6\)](#). Use the smaller value obtained from the following two equations:

$$B = AE/D_F \quad (5)$$

$$B = S_c/D_F \quad (6)$$

Step 6. Confirm that the actual calculated compressive stress shall be less than the lowest value of allowable compressive stress B . If not, a new thickness and/or operating time are chosen and [Steps 1](#) through [5](#) above are repeated.

3 EXTERNAL PRESSURE — CYLINDRICAL SHELLS

The allowable external pressure on cylindrical shells is obtained as follows:

Step 1. For any given temperature, assume a thickness t , an outside diameter, D_o , a length, L , and operating time, T .

Step 2. Calculate Factor A from Section II, Part D, Figure G using L/D_o and D_o/t .

Step 3. Calculate compressive stress S_c at a given temperature from Mandatory [Appendix I](#) of this Case for two time periods. The first time period is at less than 1 hr and the second is at the operating time period specified.

Step 4. Determine design factor D_F as follows:

(a) $T \leq 1.0$ hr

$$D_F = 3.0 \quad (7)$$

(b) $1 < T \leq 100,000$ hr

$$D_F = \frac{3}{1 + 0.0434 \ln(T)} \quad (8)$$

(c) $T > 100,000$ hr

$$D_F = 2.0 \quad (9)$$

Step 5. For each of the two time periods in [Step 3](#), calculate the allowable external pressure P given by [eqs. \(10\)](#) and [\(11\)](#). Use the smaller value obtained from the following two equations:

$$P = \frac{2AE}{(D_F)(D_o/t)} \quad (10)$$

$$P = \frac{2S_c}{(D_F)(D_o/t)} \quad (11)$$

Step 6. Confirm that the actual external pressure shall be less than the lowest value of calculated external pressure. If not, a new thickness and/or operating time are chosen and [Steps 1](#) through [5](#) above are repeated.

4 EXTERNAL PRESSURE — SPHERICAL SHELLS

The allowable external pressure on spherical shells is obtained as follows:

Step 1. For any given temperature, assume a thickness t , an outside radius R_o , and operating time, T .

Step 2. Calculate factor A from the following equation:

$$A \approx \frac{0.125}{(R_o/t)} \quad (12)$$

Step 3. Calculate compressive stress S_c at a given temperature from Mandatory [Appendix I](#) of this Case for two time periods. The first time period is for less than 1 hr and the second is at the operating time period specified.

Step 4. Determine design factor D_F as follows:

(a) $T \leq 1.0$ hr

$$D_F = 4.0 \quad (13)$$

(b) $1 < T \leq 100,000$ hr

$$D_F = \frac{4}{1 + 0.0869 \ln(T)} \quad (14)$$

(c) $T > 100,000$ hr

$$D_F = 2.0 \quad (15)$$

Step 5. For each of the two time periods in [Step 3](#), calculate the allowable external pressure, P , given by [eqs. \(16\)](#) and [\(17\)](#). Use the smaller value obtained from the following two equations.

$$P = \frac{0.25E}{(D_F)(R_o/t)^2} \quad (16)$$

$$P = \frac{2S_c}{(D_F)(R_o/t)} \quad (17)$$

Step 6. Confirm that the actual external pressure shall be less than the lowest value of calculated external pressure. If not, a new thickness and/or operating time are chosen and [Steps 1](#) through [5](#) above are repeated.

5 AXIAL COMPRESSION OF COLUMNS (EULER BUCKLING)

The allowable axial stress on a column is obtained as follows:

Step 1. Establish effective length, L , outside radius, R_o , thickness, t , and operating time, T .

Step 2. Calculate strain factor A from the following equation:

$$A = \pi^2/(\Gamma L/r)^2 \quad (18)$$

Step 3. Calculate compressive stress S_c from any of the methods given in Mandatory [Appendix I](#) of this Case for two time periods. The first time period is for less than 1 hr and the second at the operating time period specified.

Step 4. Calculate the design factor, D_F as follows:

(a) $0 < (L/r) < 120$

$$D_F = (2.78 \times 10^{-5})(L/r)^2 + 1.5 \quad (19)$$

(b) $(L/r) \geq 120$

$$D_F = 1.90 \quad (20)$$

Step 5. For each of the two time periods in [Step 3](#), calculate the allowable compressive stress σ_c given by [eqs. \(21\)](#) and [\(22\)](#). Use the smaller value obtained from the following two equations:

$$\sigma_c = \frac{AE}{D_F} \quad (21)$$

$$\sigma_c = \frac{S_c}{D_F} \quad (22)$$

Step 6. Confirm that the actual calculated compressive stress shall be less than the lowest value of allowable compressive stress σ_c . If not, a new thickness and/or operating time are chosen and [Steps 1](#) through [5](#) above are repeated.

6 REPORT

This Case number shall be shown on the Manufacturer's Data Report.

MANDATORY APPENDIX I

COMPRESSIVE STRESS, S_c

I-1 GENERAL

Compressive stress, S_c , may be obtained from either Method 1 or Method 2.

I-2 METHOD 1: EXTERNAL PRESSURE CHART (EPC)

S_c is obtained from external pressure charts in Mandatory Appendix II and listed in Table I-1. The charts are entered with a given value of A and a value of S_c is obtained for a given temperature and time curve.

I-3 METHOD 2: EQUATIONS FOR CONSTRUCTING EPC

(a) External pressure curves for the materials listed in (b) are obtained from isochronous stress-strain curves. The procedure consists of obtaining first an average isochronous stress-strain curve for a given material at a given temperature and time. Then the average isochronous stress-strain curve is minimized and used to obtain an external pressure curve as outlined below.

(b) The following are materials with available equations defining their average isochronous stress-strain curves.

- (1) Carbon steel
- (2) C-0.5Mo steel
- (3) 1.25Cr-0.5Mo annealed steel
- (4) 1.25Cr-0.5Mo normalized and tempered steel
- (5) 2.25Cr-1Mo annealed steel
- (6) 2.25Cr-1Mo normalized and tempered steel

- (7) 2.25Cr-1Mo quenched and tempered steel
- (8) 2.25Cr-Mo-V
- (9) 5Cr-1Mo steel
- (10) 9Cr-1Mo steel
- (11) 9Cr-1Mo-V steel
- (12) 12Cr steel
- (13) Type 304 and 304H stainless steel
- (14) Type 316 and 316H stainless steel
- (15) Type 321 stainless steel
- (16) Type 321H stainless steel
- (17) Type 347 stainless steel
- (18) Type 347H stainless steel
- (19) Type 347LN stainless steel
- (20) Nickel alloy 800
- (21) Nickel alloy 800H
- (22) Nickel alloy 800HT

(c) The average isochronous curve for a given material at a given temperature and time at various stress levels is obtained from the following equations.

(1) The total strain is the sum of the elastic strain, ϵ_e , plastic strain, ϵ_p , and creep strain, ϵ_c .

$$\epsilon_t = \epsilon_e + \epsilon_p + \epsilon_c \tag{I-1}$$

(2) The elastic strain is defined as follows:

$$\epsilon_e = \frac{\sigma}{E_y} \tag{I-2}$$

(3) The plastic strain is expressed as follows:

$$\epsilon_p = \gamma_1 + \gamma_2 \tag{I-3}$$

where

$$\gamma_1 = 0.5(\sigma/\alpha_3)^{(1/\alpha_2)} \left\{ 1 - \tanh \left[2 \left(\sigma - \alpha_5 \right) / \alpha_6 \right] \right\} \tag{I-4}$$

$$\gamma_2 = 0.5(\sigma/\alpha_8)^{(1/\alpha_7)} \left\{ 1 + \tanh \left[2 \left(\sigma - \alpha_5 \right) / \alpha_6 \right] \right\} \tag{I-5}$$

(4) The creep strain is defined as follows:

$$\epsilon_c = - (1/\Omega) \ln(1 - \dot{\epsilon}_{co} \Omega T) \tag{I-6}$$

where

Table I-1
External Pressure Charts in the Time-Dependent Region

Material	Temperature, °F (°C)
9Cr-1Mo-V	800 (427)
	900 (482)
	1,000 (538)
	1,100 (593)
	1,200 (649)
2.25Cr-1Mo annealed (Case 2676)	700 to 1,000 (371 to 538)
253 MA stainless steel (Case 2682)	1,200 to 1,650 (649 to 899)

$$\log_{10}(\dot{\epsilon}_{co}) = - \left[A_0 + \Delta_{\Omega}^{sr} + \frac{A_1 + A_2 S_1 + A_3 S_1^2 + A_4 S_1^3}{T_r + T_e} \right] \quad (I-7)$$

$$\log_{10}(\Omega) = B_0 + \Delta_{\Omega}^{cd} + \frac{B_1 + B_2 S_1 + B_3 S_1^2 + B_4 S_1^3}{T_r + T_e} \quad (I-8)$$

$$S_1 = \log_{10}(\sigma) \quad (I-9)$$

The values of A_i and B_i in eqs. (I-7) and (I-8) for the materials listed in (b) are given in Mandatory Appendix III.

(d) Substituting eqs. (I-2), (I-3), and (I-6) into eq. (I-1) results in an isochronous stress-strain curve at a given temperature and time for various stress levels. The obtained stress-strain relationship is used to construct the external pressure curve as detailed in the following steps.

Step 1. Calculate tangent modulus, E_t , for various stress values from the following:

$$E_t = \frac{1}{d\epsilon_c/d\sigma + d\epsilon_p/d\sigma + d\epsilon_c/d\sigma} \quad (I-10)$$

$$E_t = \frac{1}{H_1 + (H_2 + H_3) + H_4}$$

Step 2. Calculate H_1 due to the elastic component of strain.

$$H_1 = 1/E \quad (I-11)$$

From the minimum isochronous curves (0.8 times the average isochronous curves) use the following steps.

Step 3. Calculate H_2 and H_3 due to the plastic component of strain (from the minimum isochronous curves (0.8 times the average isochronous curves) using the following steps)

$$H_2 = (2\alpha_2\alpha_6\sigma_t)^{-1} \left\{ \left(\frac{\sigma_t}{\alpha_3} \right)^{1/\alpha_2} \left[\tanh \left(\frac{2\alpha_5 - 2\sigma_t}{\alpha_6} \right) + 1 \right] \right. \\ \left. \left[\alpha_6 - 2\alpha_2\sigma_t + 2\alpha_2\sigma_t \tanh \left(\frac{2\alpha_5 - 2\sigma_t}{\alpha_6} \right) \right] \right\} \quad (I-12)$$

$$H_3 = (-2\alpha_6\alpha_7\sigma_t)^{-1} \left\{ \left(\frac{\sigma_t}{\alpha_8} \right)^{1/\alpha_7} \left[\tanh \left(\frac{2\alpha_5 - 2\sigma_t}{\alpha_6} \right) - 1 \right] \right. \\ \left. \left[\alpha_6 + 2\alpha_7\sigma_t + 2\alpha_7\sigma_t \tanh \left(\frac{2\alpha_5 - 2\sigma_t}{\alpha_6} \right) \right] \right\} \quad (I-13)$$

where

$$\alpha_1 = R = \sigma_{ys}/\sigma_{ult} \quad (I-14)$$

$$\alpha_2 = m_1 = \frac{\ln(R) + (\epsilon'_p - \epsilon_{ys})}{\ln \left[\frac{\ln(1 + \epsilon'_p)}{\ln(1 + \epsilon_{ys})} \right]} \quad (I-15)$$

$$\alpha_3 = A_1 = \frac{\sigma_{ys}(1 + \epsilon_{ys})}{\ln(1 + \epsilon_{ys})^{m_1}} \quad (I-16)$$

$$\alpha_4 = K = 1.5R^{1.5} - 0.5R^{2.5} - R^{3.5} \quad (I-17)$$

$$\alpha_5 = \sigma_{ys} + K(\sigma_{ult} - \sigma_{ys}) \quad (I-18)$$

$$\alpha_6 = K(\sigma_{ult} - \sigma_{ys}) \quad (I-19)$$

$$\alpha_7 = m_2 \quad (I-20)$$

$$\alpha_8 = A_2 = \sigma_{ults} e^{m_2} / (m_2^{m_2}) \quad (I-21)$$

$$\sigma_t = (1 + \epsilon_{es})\sigma_{es} \quad (I-22)$$

The expressions ϵ'_p in eq. (I-15) and m_2 in eq. (I-20) and eq. (I-21) have temperature limitations for various materials as shown in Table III-2. When the temperature limit is exceeded, the plastic value of strain is set to zero. Also H_2 and H_3 are set to zero when the stress results in a stress that is larger than ϵ'_p .

Step 4. Calculate H_4 due to creep component of strain.

$$H_4 = C_{10}/C_7 + C_8/K_1 \quad (I-23)$$

where

$$A_{00} = A_0 + \Delta_{\Omega}^{sr} \quad (I-24)$$

$$B_{00} = B_0 + \Delta_{\Omega}^{cd} \quad (I-25)$$

$$K_1 = T_r + T_e \quad (I-26)$$

$$S_1 = \log_{10}(0.8\sigma) \quad (I-27)$$

$$C_1 = B_{00} + (B_1 + B_2 S_1 + B_3 S_1^2 + B_4 S_1^3) / K_1 \quad (I-28)$$

$$C_2 = A_{00} + (A_1 + A_2 S_1 + A_3 S_1^2 + A_4 S_1^3) / K_1 \quad (I-29)$$

$$C_3 = B_2 + 2B_3 S_1 + 3B_4 S_1^2 \quad (I-30)$$

$$C_4 = A_2 + 2A_3 S_1 + 3A_4 S_1^2 \quad (I-31)$$

$$C_5 = 10^{c_1} \left(1/10^{c_2}\right)^T C_3 \ln(10) \quad (I-32)$$

$$C_6 = \ln(10) \ln \left[1 - 10^{c_1} \left(1/10^{c_2}\right)^T\right] \quad (I-33)$$

$$C_7 = 10^{c_1} \left(1/10^{c_2}\right)^T - 1 \quad (I-34)$$

$$C_8 = \left(1/10^{c_1}\right) C_6 C_4 \quad (I-35)$$

$$C_9 = C_5 / K_1 - \left[10^{c_1} \left(1/10^{c_2}\right)^T C_4 \ln(10)\right] / K_1 \quad (I-36)$$

$$C_{10} = \left(1/10^{c_1}\right) C_9 \quad (I-37)$$

Step 5. Calculate tangent modulus, E_t , for various stress values from the following equation:

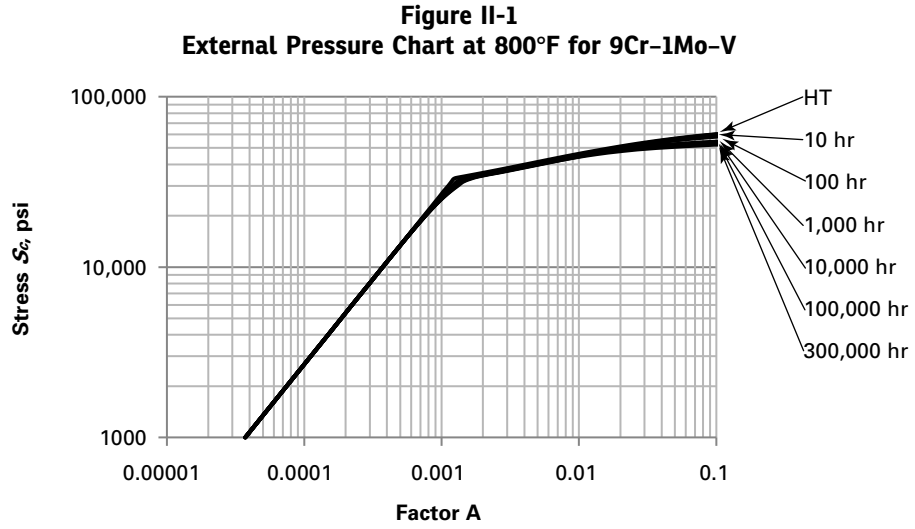
$$E_t = 1 / \left(H_1 + H_2 + H_3 + H_4\right) \quad (I-38)$$

Step 6. Determine Factor A for various σ values from the following equation:

$$A = \sigma / E_t = S_c / E_t \quad (I-39)$$

The external pressure curve correlating A to S_c is obtained by plotting A versus σ values on log-log graph correlating S_c and Factor A.

MANDATORY APPENDIX II EXTERNAL PRESSURE CHARTS



GENERAL NOTES:

- (a) $E = 26.9 \text{ E}+06 \text{ psi}$
- (b) See also [Table II-1](#) and [Table II-1.1](#).

**Table II-1
Tabular Values of A Versus S_c at 800°F**

Hot Tensile		10 hr		100 hr		1,000 hr		10,000 hr		100,000 hr		300,000 hr	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
1.00 E-05	269	1.00 E-05	269	1.00 E-05	269	1.00 E-05	269	1.00 E-05	269	1.00 E-05	269	1.00 E-05	269
1.12 E-03	30,000	3.72 E-04	10,000	3.72 E-04	10,000	5.23 E-04	14,000	5.23 E-04	14,000	5.23 E-04	14,000	5.23 E-04	14,000
2.00 E-03	36,150	4.00 E-04	10,852	4.00 E-04	10,900	6.00 E-04	16,000	6.00 E-04	16,127	6.00 E-04	16,093	6.00 E-04	16,154
3.00 E-03	38,367	5.00 E-04	13,334	5.00 E-04	13,675	7.00 E-04	18,472	7.00 E-04	18,682	7.00 E-04	18,612	7.00 E-04	18,676
4.00 E-03	40,039	6.00 E-04	15,938	6.00 E-04	16,340	8.00 E-04	20,860	8.00 E-04	21,102	8.00 E-04	20,996	8.00 E-04	21,054
5.00 E-03	41,430	7.00 E-04	18,579	7.00 E-04	18,889	9.00 E-04	23,100	9.00 E-04	23,387	9.00 E-04	23,229	9.00 E-04	23,269
6.00 E-03	42,625	8.00 E-04	21,170	8.00 E-04	21,313	1.00 E-03	25,144	1.00 E-03	25,530	1.00 E-03	25,302	1.00 E-03	25,310
7.00 E-03	43,671	9.00 E-04	23,632	9.00 E-04	23,601	1.85 E-03	34,153	1.38 E-03	32,120	1.42 E-03	32,163	1.44 E-03	32,110
8.00 E-03	44,597	1.00 E-03	25,904	1.00 E-03	25,742	2.00 E-03	34,570	2.00 E-03	33,915	2.00 E-03	33,890	2.00 E-03	34,251
9.00 E-03	45,426	2.00 E-03	35,906	1.39 E-03	32,318	3.00 E-03	36,718	3.00 E-03	36,219	3.00 E-03	36,297	3.00 E-03	36,681
1.00 E-02	46,173	2.36 E-03	35,956	2.00 E-03	34,468	4.00 E-03	38,443	4.00 E-03	38,112	4.00 E-03	38,216	4.00 E-03	38,547
2.00 E-02	51,051	3.00 E-03	37,406	3.00 E-03	36,803	5.00 E-03	39,873	5.00 E-03	39,700	5.00 E-03	39,782	5.00 E-03	40,026
3.00 E-02	53,719	4.00 E-03	39,204	4.00 E-03	38,651	6.00 E-03	41,090	6.00 E-03	41,053	6.00 E-03	41,086	6.00 E-03	41,227
4.00 E-02	55,481	5.00 E-03	40,676	5.00 E-03	40,164	7.00 E-03	42,146	7.00 E-03	42,223	7.00 E-03	42,189	7.00 E-03	42,224
5.00 E-02	56,763	6.00 E-03	41,917	6.00 E-03	41,436	8.00 E-03	43,076	8.00 E-03	43,246	8.00 E-03	43,134	8.00 E-03	43,063
6.00 E-02	57,753	7.00 E-03	42,986	7.00 E-03	42,529	9.00 E-03	43,906	9.00 E-03	44,150	9.00 E-03	43,954	9.00 E-03	43,780
7.00 E-02	58,547	8.00 E-03	43,924	8.00 E-03	43,483	1.00 E-02	44,653	1.00 E-02	44,955	1.00 E-02	44,672	1.00 E-02	44,401
8.00 E-02	59,202	9.00 E-03	44,757	9.00 E-03	44,329	2.00 E-02	49,608	2.00 E-02	49,980	2.00 E-02	48,857	2.00 E-02	47,873
9.00 E-02	59,755	1.00 E-02	45,507	1.00 E-02	45,087	3.00 E-02	52,426	3.00 E-02	52,553	3.00 E-02	50,776	3.00 E-02	49,392
1.00 E-01	60,228	2.00 E-02	50,433	2.00 E-02	50,025	4.00 E-02	54,324	4.00 E-02	54,178	4.00 E-02	51,903	4.00 E-02	50,268
...	...	3.00 E-02	53,199	3.00 E-02	52,810	5.00 E-02	55,714	5.00 E-02	55,321	5.00 E-02	52,656	5.00 E-02	50,854
...	...	4.00 E-02	55,046	4.00 E-02	54,695	6.00 E-02	56,785	6.00 E-02	56,178	6.00 E-02	53,202	6.00 E-02	51,281
...	...	5.00 E-02	56,391	5.00 E-02	56,084	7.00 E-02	57,642	7.00 E-02	56,849	7.00 E-02	53,619	7.00 E-02	51,613
...	...	6.00 E-02	57,426	6.00 E-02	57,159	8.00 E-02	58,346	8.00 E-02	57,390	8.00 E-02	53,950	8.00 E-02	51,883
...	...	7.00 E-02	58,255	7.00 E-02	58,019	9.00 E-02	58,937	9.00 E-02	57,839	9.00 E-02	54,220	9.00 E-02	52,108
...	...	8.00 E-02	58,939	8.00 E-02	58,726	1.00 E-01	59,442	1.00 E-01	58,216	1.00 E-01	54,446	1.00 E-01	52,303
...	...	9.00 E-02	59,516	9.00 E-02	59,317	...	...	...	...	...	...	...	...
...	...	1.00 E-01	60,014	1.00 E-01	59,819	...	...	...	...	...	...	...	...

Table II-1.1
Equation of A Versus S_c at 800°F

Corresponding Variables in Equation [Note (1)]	Hot Tensile		
	$A < 0.00112$	$0.00112 < A < 0.1$	
<i>a</i>	<i>AE</i>	33,307.03	
<i>b</i>	0	-944.62672	
<i>c</i>	0	-27,477,658	
<i>d</i>	0	-137,186.88	
<i>e</i>	0	-7.4842193 E+09	
<i>f</i>	0	-1,625,136.10	
<i>g</i>	0	-1.085756 E+11	

Corresponding Variables in Equation [Note (1)]	10 hr		
	$A < 0.000372$	$0.000372 < A < 0.00236$	$0.00236 < A < 0.1$
<i>a</i>	<i>AE</i>	3,392.3225	27,526.50
<i>b</i>	0	-526.13853	317.49751
<i>c</i>	0	10,856,749	14,361,808
<i>d</i>	0	477,037.25	10,024.23
<i>e</i>	0	1.038271 E+10	6.440318 E+08
<i>f</i>	0	0	-1,288.9257

Corresponding Variables in Equation [Note (1)]	100 hr		
	$A < 0.000372$	$0.000372 < A < 0.00139$	$0.00139 < A < 0.1$
<i>a</i>	<i>AE</i>	-1,200	27,008.733
<i>b</i>	0	-268.58213	256.8332
<i>c</i>	0	32,461,668	12,235,600
<i>d</i>	0	-27,817.381	5,473.2533
<i>e</i>	0	-1.314925 E+10	3.619642 E+08

Corresponding Variables in Equation [Note (1)]	1,000 hr		
	$A < 0.000523$	$0.000523 < A < 0.00185$	$0.00185 < A < 0.1$
<i>a</i>	<i>AE</i>	3,432.3766	27,900
<i>b</i>	0	-627.91172	259.10676
<i>c</i>	0	11,859,512	11,883,652
<i>d</i>	0	562,516.77	6,789.5914
<i>e</i>	0	6.900575 E+09	4.391358 E+08
<i>f</i>	0	-51,989,295	-469.27779

Corresponding Variables in Equation [Note (1)]	10,000 hr		
	$A < 0.000523$	$0.000523 < A < 0.00138$	$0.00138 < A < 0.1$
<i>a</i>	<i>AE</i>	-2,100	27,350
<i>b</i>	0	-246.16678	167.89938
<i>c</i>	0	35,346,632	8,818,383.3
<i>d</i>	0	-95,177.428	2,742.4627
<i>e</i>	0	-1.643133 E+10	1.723028 E+08

Corresponding Variables in Equation [Note (1)]	100,000 hr		
	$A < 0.000523$	$0.000523 < A < 0.00142$	$0.00142 < A < 0.1$
<i>a</i>	<i>AE</i>	-700	26,600
<i>b</i>	0	-53.625149	182.45175
<i>c</i>	0	28,655,071	9,751,975.4
<i>d</i>	0	158,460.14	1,635.0183
<i>e</i>	0	0	9.362225 E+07

Table II-1.1
Equation of A Versus S_c at 800°F (Cont'd)

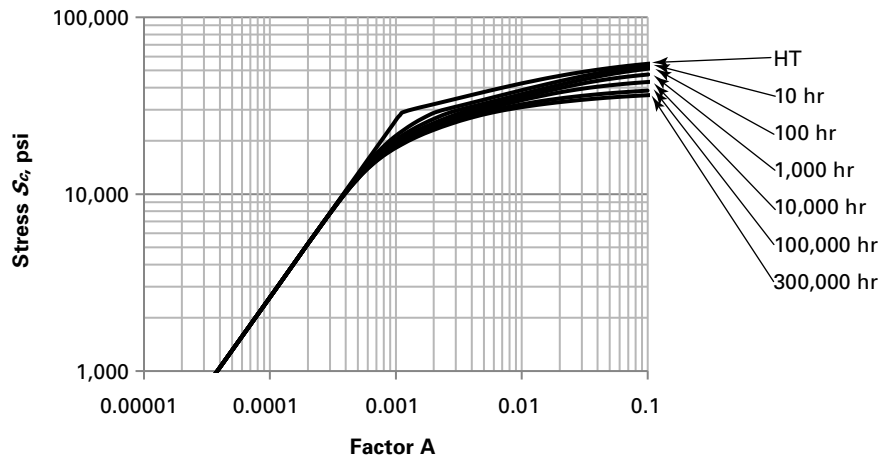
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	A < 0.000523	0.000523 < A < 0.00144	0.00144 < A < 0.1
a	AE	-625	26,231.115
b	0	-88.222411	220.27866
c	0	28,301,340	11,531,034
d	0	181,705.18	524.15689
e	0	0	29,922,776

GENERAL NOTE: E = 26.9 E+06 psi

NOTE: (1) The following equation applies to this table:

$$S_c = \frac{a + cA + eA^2 + gA^3}{1 + bA + dA^2 + fA^3}$$

Figure II-2
External Pressure Chart at 900°F for 9Cr-1Mo-V



GENERAL NOTES:

(a) E = 26.2 E+06 psi

(b) See also [Table II-2](#) and [Table II-2.1](#).

Table II-2
Tabular Values of A Versus S_c at 900°F

Hot Tensile		10 hr		100 hr		1,000 hr		10,000		100,000		300,000	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
1.00 E-05	262	1.00 E-05	262	1.00 E-05	262	1.00 E-05	262	1.00 E-05	262	1.00 E-05	262	1.00 E-05	262
1.03 E-03	27,000	5.10 E-04	13,000	3.47 E-04	9,000	2.68 E-04	7,000	2.69 E-04	7,000	2.69 E-04	7,000	2.30 E-04	6,000
2.00 E-03	32,359	6.00 E-04	15,481	4.00 E-04	10,622	3.00 E-04	7,993	3.00 E-04	7,983	3.00 E-04	7,953	3.00 E-04	8,031
3.00 E-03	34,617	7.00 E-04	17,202	5.00 E-04	13,088	4.00 E-04	10,597	4.00 E-04	10,454	4.00 E-04	10,345	4.00 E-04	10,372
4.00 E-03	36,351	8.00 E-04	18,692	6.00 E-04	15,108	5.00 E-04	12,733	5.00 E-04	12,470	5.00 E-04	12,276	5.00 E-04	12,262
5.00 E-03	37,768	9.00 E-04	19,994	7.00 E-04	16,795	6.00 E-04	14,520	6.00 E-04	14,147	6.00 E-04	13,871	6.00 E-04	13,823
6.00 E-03	38,957	1.00 E-03	21,144	8.00 E-04	18,227	7.00 E-04	16,037	7.00 E-04	15,568	7.00 E-04	15,216	7.00 E-04	15,137
7.00 E-03	39,973	2.00 E-03	27,985	9.00 E-04	19,458	8.00 E-04	17,343	8.00 E-04	16,788	8.00 E-04	16,368	8.00 E-04	16,260
8.00 E-03	40,853	3.00 E-03	31,210	1.00 E-03	20,529	9.00 E-04	18,479	9.00 E-04	17,849	9.00 E-04	17,367	9.00 E-04	17,234
9.00 E-03	41,623	4.00 E-03	33,152	2.00 E-03	26,689	1.00 E-03	19,478	1.00 E-03	18,782	1.00 E-03	18,244	1.00 E-03	18,087
1.00 E-02	42,306	5.00 E-03	34,500	3.00 E-03	29,558	2.00 E-03	25,392	2.00 E-03	24,350	2.00 E-03	23,500	2.00 E-03	23,140
1.41 E-02	44,476	6.00 E-03	35,533	4.00 E-03	31,341	3.00 E-03	28,225	3.00 E-03	27,096	3.00 E-03	26,117	3.00 E-03	25,595
2.00 E-02	46,662	7.00 E-03	36,388	5.00 E-03	32,637	4.00 E-03	29,994	4.00 E-03	28,855	4.00 E-03	27,785	4.00 E-03	27,130
3.00 E-02	49,004	8.00 E-03	37,140	6.00 E-03	33,677	5.00 E-03	31,275	5.00 E-03	30,142	5.00 E-03	28,981	5.00 E-03	28,214
4.00 E-02	50,538	9.00 E-03	37,837	7.00 E-03	34,567	6.00 E-03	32,295	6.00 E-03	31,161	6.00 E-03	29,898	6.00 E-03	29,036
5.00 E-02	51,643	1.00 E-02	38,514	8.00 E-03	35,365	7.00 E-03	33,163	7.00 E-03	32,009	7.00 E-03	30,633	7.00 E-03	29,689
6.00 E-02	52,487	1.12 E-02	39,335	9.00 E-03	36,103	8.00 E-03	33,937	8.00 E-03	32,737	8.00 E-03	31,239	8.00 E-03	30,225
7.00 E-02	53,160	2.00 E-02	43,523	1.00 E-02	36,803	9.00 E-03	34,650	9.00 E-03	33,378	9.00 E-03	31,750	8.60 E-03	30,503
8.00 E-02	53,712	3.00 E-02	46,334	1.11 E-02	37,545	1.03 E-02	35,522	1.00 E-02	33,952	1.00 E-02	32,188	9.00 E-03	30,665
9.00 E-02	54,174	4.00 E-02	48,233	2.00 E-02	41,539	2.00 E-02	39,747	1.33 E-02	35,509	1.08 E-02	32,497	1.00 E-02	31,032
1.00 E-01	54,569	5.00 E-02	49,621	3.00 E-02	44,338	3.00 E-02	42,191	2.00 E-02	37,619	2.00 E-02	34,758	2.00 E-02	33,131
...	...	6.00 E-02	50,691	4.00 E-02	46,231	4.00 E-02	43,749	3.00 E-02	39,420	3.00 E-02	35,956	3.00 E-02	34,128
...	...	7.00 E-02	51,543	5.00 E-02	47,605	5.00 E-02	44,832	4.00 E-02	40,505	4.00 E-02	36,690	4.00 E-02	34,748
...	...	8.00 E-02	52,242	6.00 E-02	48,651	6.00 E-02	45,631	5.00 E-02	41,245	5.00 E-02	37,200	5.00 E-02	35,182
...	...	9.00 E-02	52,826	7.00 E-02	49,477	7.00 E-02	46,247	6.00 E-02	41,789	6.00 E-02	37,583	6.00 E-02	35,509
...	...	1.00 E-01	53,322	8.00 E-02	50,148	8.00 E-02	46,736	7.00 E-02	42,212	7.00 E-02	37,884	7.00 E-02	35,765
...	...	...	...	9.00 E-02	50,705	9.00 E-02	47,137	8.00 E-02	42,553	8.00 E-02	38,128	8.00 E-02	35,972
...	1.00 E-01	51,175	1.00 E-01	47,471	9.00 E-02	42,836	9.00 E-02	38,331	9.00 E-02	36,144
...	1.00 E-01	43,076	1.00 E-01	38,503	1.00 E-01	36,289

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Table II-2.1
Equation of A Versus S_c at 900°F

Corresponding Variables in Equation [Note (1)]	Hot Tensile		
	$A < 0.00103$	$0.00103 < A < 0.0141$	$0.0141 < A < 0.1$
<i>a</i>	<i>AE</i>	27,964.167	31,327.386
<i>b</i>	0	-1,093.6821	102.34923
<i>c</i>	0	-26,012,815	5,281,452
<i>d</i>	0	-116,800.63	973.22158
<i>e</i>	0	-7.7168820 E+09	5.8469333 E+07
<i>f</i>	0	8,479,773.40	0
<i>g</i>	0	4.480790 E+11	0
Corresponding Variables in Equation [Note (1)]	10 hr		
	$A < 0.00051$	$0.00051 < A < 0.0112$	$0.0112 < A < 0.1$
<i>a</i>	<i>AE</i>	-5,435.0786	27,485.33
<i>b</i>	0	1,439.5077	101.64159
<i>c</i>	0	57,848,105	4,756,057.2
<i>d</i>	0	-59,411.001	1,455.434
<i>e</i>	0	-2.089394 E+09	8.682607 E+07
Corresponding Variables in Equation [Note (1)]	100 hr		
	$A < 0.000347$	$0.000347 < A < 0.0111$	$0.0111 < A < 0.1$
<i>a</i>	<i>AE</i>	-9,150	27,800
<i>b</i>	0	2,031.3851	57.948237
<i>c</i>	0	70,911,205	2,979,758
<i>d</i>	0	-22,947.027	365.2436
<i>e</i>	0	0	2.088640 E+07
Corresponding Variables in Equation [Note (1)]	1,000 hr		
	$A < 0.000268$	$0.000268 < A < 0.0103$	$0.0103 < A < 0.1$
<i>a</i>	<i>AE</i>	-4,950	25,000
<i>b</i>	0	1,650.2558	67.781989
<i>c</i>	0	56,348,889	3,429,321.2
<i>d</i>	0	-23,663.358	-2.7483014
<i>e</i>	0	-2.385313 E+08	0
Corresponding Variables in Equation [Note (1)]	10,000 hr		
	$A < 0.000269$	$0.000269 < A < 0.0133$	$0.0133 < A < 0.1$
<i>a</i>	<i>AE</i>	-4,625.6955	20,479.985
<i>b</i>	0	1,838.9162	139.23122
<i>c</i>	0	55,864,317	5,976,308
<i>d</i>	0	68,472.463	632.11783
<i>e</i>	0	3.367557 E+09	2.970163 E+07
Corresponding Variables in Equation [Note (1)]	100,000 hr		
	$A < 0.000269$	$0.000269 < A < 0.0108$	$0.0108 < A < 0.1$
<i>a</i>	<i>AE</i>	-4,800	17,944.433
<i>b</i>	0	2,170.7464	278.66649
<i>c</i>	0	57,392,294	10,056,596
<i>d</i>	0	260,922.72	3,926.4111
<i>e</i>	0	1.001664 E+10	1.599647 E+08
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	$A < 0.00023$	$0.00023 < A < 0.0086$	$0.0086 < A < 0.1$
<i>a</i>	<i>AE</i>	-4,390	17,996.056
<i>b</i>	0	2,118.9741	352.2657
<i>c</i>	0	56,354,875	11,757,555

Table II-2.1
Equation of A Versus S_c at 900°F (Cont'd)

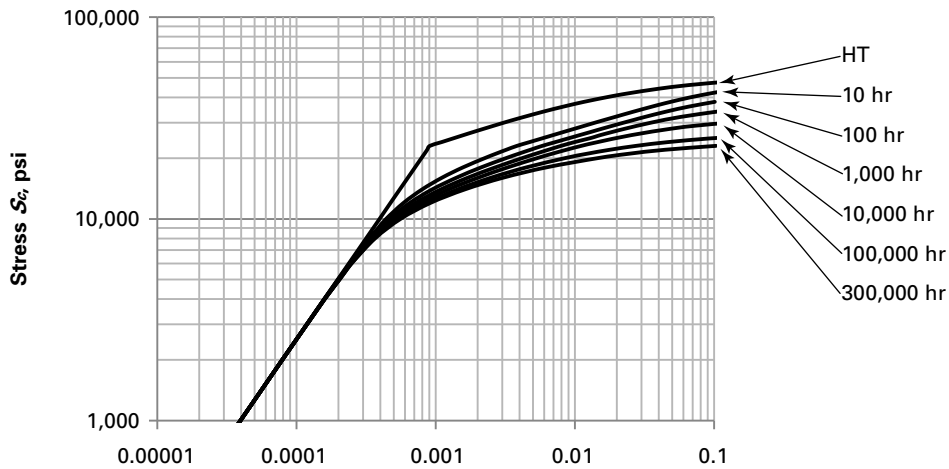
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	A < 0.00023	0.00023 < A < 0.0086	0.0086 < A < 0.1
d	0	242,642.88	6,786.9067
e	0	8.836059 E+09	2.58 E+08

GENERAL NOTE: E = 26.2 E+06 psi

NOTE: (1) The following equation applies to this table:

$$S_c = \frac{a + cA + eA^2 + gA^3}{1 + bA + dA^2 + fA^3}$$

Figure II-3
External Pressure Chart at 1,000°F for 9Cr-1Mo-V



GENERAL NOTES:

(a) E = 25.4 E+06 psi

(b) See also [Table II-3](#) and [Table II-3.1](#).

**Table II-3
Tabular Values of A Versus S_c at 1,000°F**

Hot Tensile		10 hr		100 hr		1,000 hr		10,000 hr		100,000 hr		300,000 hr	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
1.00 E-05	254	1.00 E-05	254	1.00 E-05	254	1.00 E-05	254	1.00 E-05	254	1.00 E-05	254	1.00 E-05	254
9.07 E-04	23,000	1.19 E-04	3,000	2.00 E-04	5,000	1.59 E-04	4,000	1.70 E-04	4,250	1.59 E-04	4,000	1.59 E-04	4,000
1.00 E-03	23,552	2.00 E-04	5,271	3.00 E-04	7,319	2.00 E-04	5,135	2.00 E-04	5,125	2.00 E-04	5,146	2.00 E-04	5,140
2.00 E-03	27,391	3.00 E-04	7,475	4.00 E-04	8,986	3.00 E-04	7,202	3.00 E-04	7,242	3.00 E-04	7,151	3.00 E-04	7,131
3.00 E-03	29,824	4.00 E-04	9,237	5.00 E-04	10,291	4.00 E-04	8,726	4.00 E-04	8,740	4.00 E-04	8,575	4.00 E-04	8,509
4.00 E-03	31,582	5.00 E-04	10,681	6.00 E-04	11,348	5.00 E-04	9,909	5.00 E-04	9,871	5.00 E-04	9,649	5.00 E-04	9,531
5.00 E-03	32,950	6.00 E-04	11,888	7.00 E-04	12,228	6.00 E-04	10,862	6.00 E-04	10,765	6.00 E-04	10,495	6.00 E-04	10,327
6.00 E-03	34,066	7.00 E-04	12,916	8.00 E-04	12,976	7.00 E-04	11,654	7.00 E-04	11,497	7.00 E-04	11,182	7.00 E-04	10,971
7.00 E-03	35,004	8.00 E-04	13,803	9.00 E-04	13,624	8.00 E-04	12,327	8.00 E-04	12,113	8.00 E-04	11,757	8.00 E-04	11,507
8.00 E-03	35,811	9.00 E-04	14,578	1.00 E-03	14,194	9.00 E-04	12,911	9.00 E-04	12,643	9.00 E-04	12,248	9.00 E-04	11,964
9.00 E-03	36,516	1.00 E-03	15,263	2.00 E-03	17,739	1.00 E-03	13,425	1.00 E-03	13,107	1.00 E-03	12,674	1.00 E-03	12,359
1.00 E-02	37,140	2.00 E-03	19,461	3.00 E-03	19,718	2.00 E-03	16,659	2.00 E-03	15,993	2.00 E-03	15,242	2.00 E-03	14,719
1.16 E-02	38,005	3.00 E-03	21,657	4.00 E-03	21,121	3.00 E-03	18,504	3.00 E-03	17,633	3.00 E-03	16,643	3.00 E-03	15,960
2.00 E-02	40,939	4.00 E-03	23,144	5.00 E-03	22,214	4.00 E-03	19,823	4.00 E-03	18,806	4.00 E-03	17,628	3.05 E-03	16,009
3.00 E-02	42,899	5.00 E-03	24,288	6.00 E-03	23,111	5.00 E-03	20,855	5.00 E-03	19,725	5.00 E-03	18,383	4.00 E-03	16,777
4.00 E-02	44,148	6.00 E-03	25,232	7.00 E-03	23,868	6.00 E-03	21,699	6.00 E-03	20,480	6.00 E-03	18,982	5.00 E-03	17,394
5.00 E-02	45,032	7.00 E-03	26,046	7.21 E-03	24,013	7.00 E-03	22,410	7.00 E-03	21,118	7.00 E-03	19,463	6.00 E-03	17,884
6.00 E-02	45,701	8.00 E-03	26,766	8.00 E-03	24,503	8.00 E-03	23,020	8.00 E-03	21,668	8.00 E-03	19,847	7.00 E-03	18,285
7.00 E-02	46,228	9.00 E-03	27,417	9.00 E-03	25,060	9.00 E-03	23,551	9.00 E-03	22,151	8.49 E-03	20,006	8.00 E-03	18,621
8.00 E-02	46,657	1.00 E-02	28,012	1.00 E-02	25,579	1.00 E-02	24,017	1.00 E-02	22,580	9.00 E-03	20,173	9.00 E-03	18,909
9.00 E-02	47,013	1.40 E-02	30,000	2.00 E-02	29,348	1.39 E-02	25,411	1.11 E-02	23,002	1.00 E-02	20,474	1.00 E-02	19,160
1.00 E-01	47,316	2.00 E-02	32,183	3.00 E-02	31,669	2.00 E-02	27,342	2.00 E-02	25,174	2.00 E-02	22,278	2.00 E-02	20,646
...	...	3.00 E-02	34,832	4.00 E-02	33,296	3.00 E-02	29,246	3.00 E-02	26,543	3.00 E-02	23,177	3.00 E-02	21,384
...	...	4.00 E-02	36,735	5.00 E-02	34,532	4.00 E-02	30,528	4.00 E-02	27,415	4.00 E-02	23,741	4.00 E-02	21,848
...	...	5.00 E-02	38,175	6.00 E-02	35,524	5.00 E-02	31,460	5.00 E-02	28,026	5.00 E-02	24,135	5.00 E-02	22,172
...	...	6.00 E-02	39,307	7.00 E-02	36,344	6.00 E-02	32,169	6.00 E-02	28,484	6.00 E-02	24,430	6.00 E-02	22,412
...	...	7.00 E-02	40,224	8.00 E-02	37,030	7.00 E-02	32,727	7.00 E-02	28,842	7.00 E-02	24,660	7.00 E-02	22,599
...	...	8.00 E-02	40,984	9.00 E-02	37,585	8.00 E-02	33,178	8.00 E-02	29,131	8.00 E-02	24,845	8.00 E-02	22,748
...	...	9.00 E-02	41,627	1.00 E-01	37,973	9.00 E-02	33,550	9.00 E-02	29,370	9.00 E-02	24,997	9.00 E-02	22,871
...	...	1.00 E-01	42,178	...	...	1.00 E-01	33,862	1.00 E-01	29,572	1.00 E-01	25,124	1.00 E-01	22,973

Table II-3.1
Equation of A Versus S_c at 1,000°F

Corresponding Variables in Equation [Note (1)]	Hot Tensile		
	$A < 0.000907$	$0.000907 < A < 0.0116$	$0.0116 < A < 0.1$
<i>a</i>	<i>AE</i>	15,600	24,677.21
<i>b</i>	0	762.67756	150.47277
<i>c</i>	0	24,665,999	6,555,769
<i>d</i>	0	49,064.031	2,035.3028
<i>e</i>	0	2.4035820 E+09	1.0420478 E+08
Corresponding Variables in Equation [Note (1)]	10 hr		
	$A < 0.000119$	$0.000119 < A < 0.014$	$0.014 < A < 0.1$
<i>a</i>	<i>AE</i>	-1415.0514	21,582.144
<i>b</i>	0	1,813.0367	36.417634
<i>c</i>	0	42,500,284	1,675,388.9
<i>d</i>	0	59,994.423	66.978226
<i>e</i>	0	2.719414 E+09	3.491120 E+06
Corresponding Variables in Equation [Note (1)]	100 hr		
	$A < 0.0002$	$0.0002 < A < 0.00721$	$0.00721 < A < 0.1$
<i>a</i>	<i>AE</i>	-3,028.8724	-17,901.869
<i>b</i>	0	3,040.0306	48.196408
<i>c</i>	0	54,298,553	2,047,594.8
<i>d</i>	0	301,719.7	-475.20663
<i>e</i>	0	1.035902 E+10	-1.676553 E+07
<i>f</i>	0	0	380.9856
Corresponding Variables in Equation [Note (1)]	1,000 hr		
	$A < 0.000159$	$0.000159 < A < 0.0139$	$0.0139 < A < 0.1$
<i>a</i>	<i>AE</i>	-2,762.6546	19,873.546
<i>b</i>	0	3,415.3795	-73.002048
<i>c</i>	0	54,970,975	-701,480.94
<i>d</i>	0	386,549.9	-4,563.0882
<i>e</i>	0	1.225752 E+10	1.708215 E+08
Corresponding Variables in Equation [Note (1)]	10,000 hr		
	$A < 0.00017$	$0.00017 < A < 0.0111$	$0.0111 < A < 0.1$
<i>a</i>	<i>AE</i>	-4,100	15,488.498
<i>b</i>	0	4,389.4521	108.58297
<i>c</i>	0	65,950,953	3,056,392.6
<i>d</i>	0	574,934.53	1,162.6443
<i>e</i>	0	1.630781 E+10	3.733611 E+07
<i>f</i>	0	-1,140,419.7	0
Corresponding Variables in Equation [Note (1)]	100,000 hr		
	$A < 0.000159$	$0.000159 < A < 0.00849$	$0.00849 < A < 0.1$
<i>a</i>	<i>AE</i>	-3,300	12,255.784
<i>b</i>	0	3,927.0281	260.45285
<i>c</i>	0	61,252,738	5,792,090.9
<i>d</i>	0	180,367.13	5,894.3349
<i>e</i>	0	6.843272 E+09	1.568939 E+08
<i>f</i>	0	5,137,728.1	0
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	$A < 0.000159$	$0.000159 < A < 0.00305$	$0.00305 < A < 0.1$
<i>a</i>	<i>AE</i>	-4,150	9,985.1055
<i>b</i>	0	4,931.0826	446.16032

Table II-3.1
Equation of A Versus S_c at 1,000°F (Cont'd)

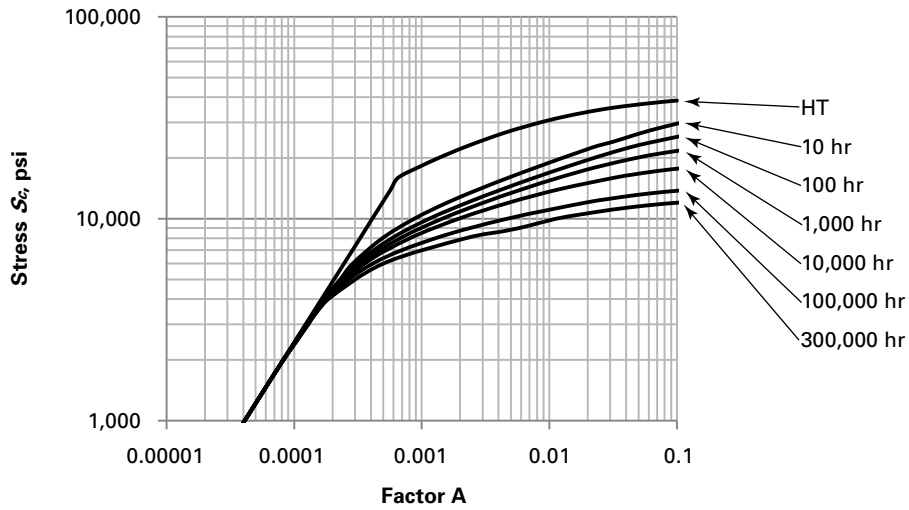
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	$A < 0.000159$	$0.000159 < A < 0.00305$	$0.00305 < A < 0.1$
c	0	68,833,229	8,771,715.2
d	0	860,066.2	13,996.708
e	0	1.925057 E+10	3.376168 E+08

GENERAL NOTE: E = 25.4 E+06 psi

NOTE: (1) The following equation applies to this table:

$$S_c = \frac{a + cA + eA^2}{1 + bA + dA^2 + fA^3}$$

Figure II-4
External Pressure Chart at 1,100°F for 9Cr-1Mo-V



GENERAL NOTES:

(a) E = 24.4 E+06 psi

(b) See also [Table II-4](#) and [Table II-4.1](#).

Table II-4
Tabular Values of A Versus S_c at 1,100°F

Hot Tensile		10 hr		100 hr		1,000 hr		10,000 hr		100,000 hr		300,000 hr	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
1.00 E-05	244	1.00 E-05	244	1.00 E-05	244	1.00 E-05	244	1.00 E-05	244	1.00 E-05	244	1.00 E-05	244
6.55 E-04	16,000	1.26 E-04	3,000	8.22 E-05	2,000	1.06 E-04	2,500	4.10 E-05	1,000	8.25 E-05	2,000	8.25 E-05	2,000
7.00 E-04	16,381	2.00 E-04	4,591	9.00 E-05	2,235	2.00 E-04	4,248	5.00 E-05	1,317	9.00 E-05	2,220	9.00 E-05	2,204
8.00 E-04	17,073	3.00 E-04	6,066	1.00 E-04	2,510	3.00 E-04	5,463	6.00 E-05	1,600	1.00 E-04	2,473	1.00 E-04	2,422
9.00 E-04	17,701	4.00 E-04	7,150	2.00 E-04	4,576	4.00 E-04	6,353	7.00 E-05	1,866	2.00 E-04	4,245	2.00 E-04	3,999
1.00 E-03	18,274	5.00 E-04	7,989	3.00 E-04	5,903	5.00 E-04	7,039	8.00 E-05	2,116	3.00 E-04	5,267	3.00 E-04	4,943
2.00 E-03	22,191	6.00 E-04	8,666	4.00 E-04	6,843	6.00 E-04	7,590	9.00 E-05	2,351	4.00 E-04	5,937	4.00 E-04	5,573
3.00 E-03	24,489	7.00 E-04	9,229	5.00 E-04	7,558	7.00 E-04	8,047	1.00 E-04	2,574	5.00 E-04	6,414	5.00 E-04	6,023
4.00 E-03	26,084	8.00 E-04	9,709	6.00 E-04	8,127	8.00 E-04	8,434	2.00 E-04	4,274	6.00 E-04	6,774	6.00 E-04	6,362
5.00 E-03	27,292	9.00 E-04	10,125	7.00 E-04	8,598	9.00 E-04	8,769	3.00 E-04	5,384	7.00 E-04	7,058	7.00 E-04	6,626
6.00 E-03	28,257	1.00 E-03	10,493	8.00 E-04	8,998	1.00 E-03	9,064	4.00 E-04	6,177	8.00 E-04	7,289	8.00 E-04	6,839
7.00 E-03	29,053	2.00 E-03	12,853	9.00 E-04	9,346	2.00 E-03	10,922	5.00 E-04	6,780	9.00 E-04	7,483	9.00 E-04	7,013
8.00 E-03	29,728	3.00 E-03	14,257	1.00 E-03	9,653	3.00 E-03	11,997	6.00 E-04	7,259	1.00 E-03	7,649	1.00 E-03	7,160
9.00 E-03	30,310	4.00 E-03	15,301	2.00 E-03	11,660	4.00 E-03	12,784	7.00 E-04	7,652	2.00 E-03	8,630	2.00 E-03	7,918
1.00 E-02	30,818	5.00 E-03	16,147	3.00 E-03	12,884	5.00 E-03	13,414	8.00 E-04	7,985	3.00 E-03	9,212	3.00 E-03	8,237
2.00 E-02	33,847	6.00 E-03	16,864	4.00 E-03	13,799	6.00 E-03	13,941	9.00 E-04	8,272	4.00 E-03	9,701	4.00 E-03	8,430
3.00 E-02	35,328	7.00 E-03	17,487	5.00 E-03	14,536	7.00 E-03	14,396	1.00 E-03	8,523	4.64 E-03	10,001	4.45 E-03	8,498
4.00 E-02	36,247	8.00 E-03	18,039	6.00 E-03	15,153	8.00 E-03	14,796	2.00 E-03	10,093	5.00 E-03	10,145	5.00 E-03	8,652
5.00 E-02	36,886	9.00 E-03	18,536	7.00 E-03	15,682	9.00 E-03	15,151	3.00 E-03	10,981	6.00 E-03	10,404	6.00 E-03	8,906
6.00 E-02	37,364	1.00 E-02	18,987	7.68 E-03	16,002	1.00 E-02	15,472	4.00 E-03	11,613	7.00 E-03	10,621	7.00 E-03	9,126
7.00 E-02	37,737	2.00 E-02	22,149	8.00 E-03	16,159	2.00 E-02	17,575	5.00 E-03	12,105	8.00 E-03	10,810	8.00 E-03	9,320
8.00 E-02	38,039	2.39 E-02	23,043	1.00 E-02	16,906	3.00 E-02	18,758	6.00 E-03	12,508	9.00 E-03	10,975	9.00 E-03	9,492
9.00 E-02	38,289	3.00 E-02	24,010	2.00 E-02	19,572	4.00 E-02	19,554	7.00 E-03	12,848	1.00 E-02	11,123	1.00 E-02	9,646
1.00 E-01	38,500	4.00 E-02	25,326	3.00 E-02	21,213	5.00 E-02	20,142	8.00 E-03	13,141	2.00 E-02	12,076	2.00 E-02	10,596
...	...	5.00 E-02	26,424	4.00 E-02	22,333	6.00 E-02	20,599	9.00 E-03	13,398	3.00 E-02	12,590	3.00 E-02	11,061
...	...	6.00 E-02	27,342	5.00 E-02	23,151	7.00 E-02	20,967	1.00 E-02	13,627	4.00 E-02	12,923	4.00 E-02	11,340
...	...	7.00 E-02	28,109	6.00 E-02	23,781	8.00 E-02	21,272	2.00 E-02	15,070	5.00 E-02	13,159	5.00 E-02	11,530
...	...	8.00 E-02	28,750	7.00 E-02	24,289	9.00 E-02	21,529	3.00 E-02	15,848	6.00 E-02	13,339	6.00 E-02	11,669
...	...	9.00 E-02	29,284	8.00 E-02	24,715	1.00 E-01	21,749	4.00 E-02	16,361	7.00 E-02	13,481	7.00 E-02	11,776
...	...	1.00 E-01	29,726	9.00 E-02	25,088	...	...	5.00 E-02	16,733	8.00 E-02	13,597	8.00 E-02	11,863
...	1.00 E-01	25,430	6.00 E-02	17,018	9.00 E-02	13,693	9.00 E-02	11,936
...	7.00 E-02	17,245	1.00 E-01	13,772	1.00 E-01	11,998
...	8.00 E-02	17,430
...	9.00 E-02	17,585

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**Table II-4
Tabular Values of A Versus S_c at 1,100°F (Cont'd)**

Hot Tensile		10 hr		100 hr		1,000 hr		10,000 hr		100,000 hr		300,000 hr	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
...	1.00 E-01	17,717	...	...	...	...

Table II-4.1
Equation of A Versus S_c at 1,100°F

Corresponding Variables in Equation [Note (1)]	Hot Tensile		
	$A < 0.000655$	$0.000655 < A < 0.1$	
<i>a</i>	<i>AE</i>	8,108.2914	
<i>b</i>	0	1,181.5642	
<i>c</i>	0	29,235,051	
<i>d</i>	0	136,007.9	
<i>e</i>	0	4.9706220 E+09	
<i>f</i>	0	1,598,683.60	
<i>g</i>	0	6.586205 E+10	
Corresponding Variables in Equation [Note (1)]	10 hr		
	$A < 0.000126$	$0.000126 < A < 0.0239$	$0.0239 < A < 0.1$
<i>a</i>	<i>AE</i>	-1,140	18,200
<i>b</i>	0	3,536.0981	9.3141382
<i>c</i>	0	43,404,767	425,372.13
<i>d</i>	0	353,872.23	11.181658
<i>e</i>	0	9.033107 E+09	0
<i>f</i>	0	-1,373,869.8	0
Corresponding Variables in Equation [Note (1)]	100 hr		
	$A < 0.0000822$	$0.0000822 < A < 0.00768$	$0.00768 < A < 0.1$
<i>a</i>	<i>AE</i>	-1290	11,787.381
<i>b</i>	0	4,608.8078	40.525951
<i>c</i>	0	48,472,367	1,226,276.9
<i>d</i>	0	551,752.87	-273.5062
<i>e</i>	0	1.227712 E+10	-7.548069 E+06
<i>f</i>	0	-1,113,258.7	0
Corresponding Variables in Equation [Note (1)]	1,000 hr		
	$A < 0.0001057$	$0.0001057 < A < 0.1$	
<i>a</i>	<i>AE</i>	-495.88388	
<i>b</i>	0	3,559.1794	
<i>c</i>	0	37,590,499	
<i>d</i>	0	432,774.92	
<i>e</i>	0	8.059657 E+09	
<i>f</i>	0	5,861,803.8	
<i>g</i>	0	1.450160 E+11	
<i>h</i>	0	163,854.14	
Corresponding Variables in Equation [Note (1)]	10,000 hr		
	$A < 0.000041$	$0.000041 < A < 0.1$	
<i>a</i>	<i>AE</i>	-432.0064	
<i>b</i>	0	4,256.832	
<i>c</i>	0	40,051,096	
<i>d</i>	0	773,433.38	
<i>e</i>	0	1.161357 E+10	
<i>f</i>	0	15,199,847	
<i>g</i>	0	2.933055 E+11	
<i>h</i>	0	-245,566.19	
Corresponding Variables in Equation [Note (1)]	100,000 hr		
	$A < 0.0000825$	$0.0000825 < A < 0.00464$	$0.00464 < A < 0.1$
<i>a</i>	<i>AE</i>	-1,420	1,343.2247
<i>b</i>	0	6,049.6909	2,373.7664

Table II-4.1
Equation of A Versus S_c at 1,100°F (Cont'd)

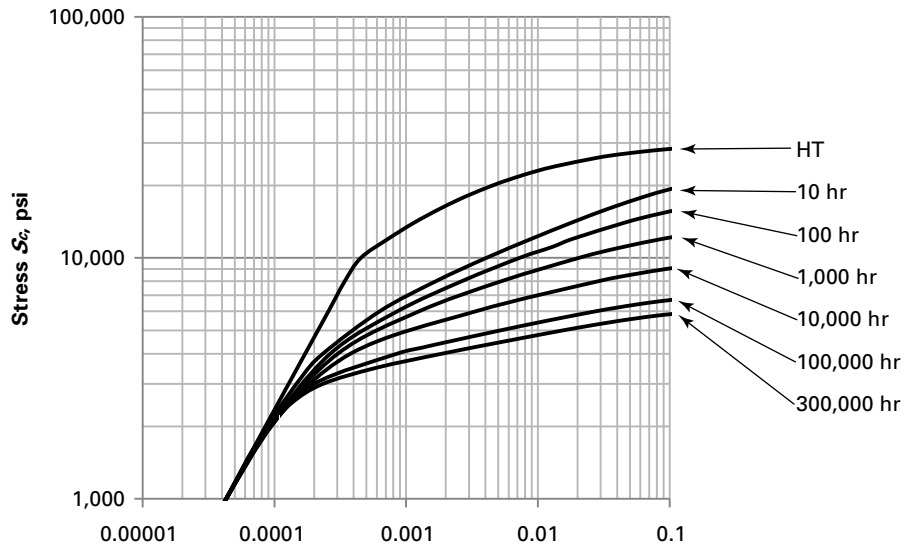
Corresponding Variables in Equation [Note (1)]	100,000 hr		
	$A < 0.0000825$	$0.0000825 < A < 0.00464$	$0.00464 < A < 0.1$
<i>c</i>	0	53,838,612	22,982,321
<i>d</i>	0	-196,668.59	127,135.51
<i>e</i>	0	0	1.878808 E+09
<i>f</i>	0	0	-910342.26
<i>g</i>	0	0	-1.257566 E+10
<i>h</i>	0	0	186,560.41
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	$A < 0.0000825$	$0.0000825 < A < 0.00445$	$0.00445 < A < 0.1$
<i>a</i>	<i>AE</i>	-750	6,500
<i>b</i>	0	5,072.3258	117.41846
<i>c</i>	0	44,002,971	1,445,804
<i>d</i>	0	-31,264.624	-14.964643

GENERAL NOTE: E = 24.4 E+06 psi

NOTE: (1) The following equation applies to this table:

$$S_c = \frac{a + cA + eA^2 + gA^3}{1 + bA + dA^2 + fA^3 + hA^4}$$

Figure II-5
External Pressure Chart at 1,200°F for 9Cr-1Mo-V



GENERAL NOTES:

(a) E = 23.3 +E06 psi

(b) See also [Table II-5](#) and [Table II-5.1](#).

**Table II-5
Tabular Values of A Versus S_c at 1,200°F**

Hot Tensile		10 hr		100 hr		1,000 hr		10,000 hr		100,000 hr		300,000 hr	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
1.00 E-05	233	1.00 E-05	233	1.00 E-05	233	1.00 E-05	233	1.00 E-05	233	1.00 E-05	233	1.00 E-05	233
3.42 E-04	8,000	8.84 E-05	2,000	4.30 E-05	1,000	4.30 E-05	1,000	4.31 E-05	1,000	4.31 E-05	1,000	4.31 E-05	1,000
4.00 E-04	9,303	9.00 E-05	2,089	5.00 E-05	1,204	5.00 E-05	1,191	5.00 E-05	1,189	5.00 E-05	1,217	5.00 E-05	1,203
5.00 E-04	10,458	1.00 E-04	2,266	6.00 E-05	1,456	6.00 E-05	1,429	6.00 E-05	1,424	6.00 E-05	1,473	6.00 E-05	1,445
6.00 E-04	11,245	2.00 E-04	3,599	7.00 E-05	1,685	7.00 E-05	1,645	7.00 E-05	1,635	7.00 E-05	1,688	7.00 E-05	1,647
7.00 E-04	11,884	3.00 E-04	4,458	8.00 E-05	1,895	8.00 E-05	1,842	8.00 E-05	1,824	8.00 E-05	1,871	8.00 E-05	1,817
8.00 E-04	12,439	4.00 E-04	5,071	9.00 E-05	2,088	9.00 E-05	2,023	9.00 E-05	1,995	9.00 E-05	2,029	9.00 E-05	1,963
9.00 E-04	12,933	5.00 E-04	5,541	1.00 E-04	2,265	1.00 E-04	2,189	1.00 E-04	2,151	1.00 E-04	2,167	1.00 E-04	2,090
1.00 E-03	13,382	6.00 E-04	5,918	2.00 E-04	3,507	2.00 E-04	3,334	2.00 E-04	3,175	2.00 E-04	2,961	2.00 E-04	2,804
2.00 E-03	16,449	7.00 E-04	6,233	3.00 E-04	4,239	3.00 E-04	3,994	3.00 E-04	3,723	3.00 E-04	3,325	3.00 E-04	3,121
3.00 E-03	18,240	8.00 E-04	6,504	4.00 E-04	4,742	4.00 E-04	4,437	4.00 E-04	4,073	4.00 E-04	3,543	4.00 E-04	3,305
4.00 E-03	19,461	9.00 E-04	6,741	5.00 E-04	5,121	5.00 E-04	4,764	5.00 E-04	4,321	5.00 E-04	3,693	5.00 E-04	3,429
5.00 E-03	20,373	1.00 E-03	6,952	6.00 E-04	5,425	6.00 E-04	5,022	6.00 E-04	4,509	6.00 E-04	3,807	6.00 E-04	3,521
5.85 E-03	21,000	2.00 E-03	8,377	7.00 E-04	5,679	7.00 E-04	5,234	7.00 E-04	4,659	7.00 E-04	3,897	7.00 E-04	3,593
6.00 E-03	21,110	3.00 E-03	9,280	8.00 E-04	5,899	8.00 E-04	5,414	8.00 E-04	4,784	8.00 E-04	3,973	8.00 E-04	3,653
7.00 E-03	21,692	4.00 E-03	9,966	9.00 E-04	6,094	9.00 E-04	5,570	9.00 E-04	4,890	9.00 E-04	4,038	9.00 E-04	3,703
8.00 E-03	22,186	5.00 E-03	10,519	1.00 E-03	6,269	1.00 E-03	5,709	1.00 E-03	4,982	1.00 E-03	4,095	1.00 E-03	3,747
9.00 E-03	22,611	6.00 E-03	10,982	2.00 E-03	7,479	2.00 E-03	6,628	2.00 E-03	5,562	2.00 E-03	4,466	2.00 E-03	4,030
1.00 E-02	22,982	7.00 E-03	11,377	3.00 E-03	8,252	3.00 E-03	7,188	3.00 E-03	5,903	3.00 E-03	4,690	3.00 E-03	4,207
2.00 E-02	25,148	8.00 E-03	11,718	4.00 E-03	8,823	4.00 E-03	7,599	4.00 E-03	6,154	4.00 E-03	4,853	4.00 E-03	4,340
3.00 E-02	26,176	8.94 E-03	12,001	5.00 E-03	9,269	5.00 E-03	7,923	5.00 E-03	6,355	5.00 E-03	4,981	5.00 E-03	4,449
4.00 E-02	26,803	9.00 E-03	12,018	6.00 E-03	9,631	6.00 E-03	8,191	6.00 E-03	6,522	5.17 E-03	5,000	6.00 E-03	4,540
5.00 E-02	27,236	1.00 E-02	12,300	7.00 E-03	9,931	7.00 E-03	8,418	7.00 E-03	6,666	6.00 E-03	5,084	7.00 E-03	4,617
6.00 E-02	27,555	2.00 E-02	14,320	8.00 E-03	10,184	8.00 E-03	8,615	8.00 E-03	6,791	7.00 E-03	5,174	8.00 E-03	4,685
7.00 E-02	27,803	3.00 E-02	15,580	9.00 E-03	10,400	9.00 E-03	8,789	9.00 E-03	6,903	8.00 E-03	5,253	9.00 E-03	4,744
8.00 E-02	28,002	4.00 E-02	16,484	1.00 E-02	10,588	1.00 E-02	8,945	1.00 E-02	7,003	9.00 E-03	5,324	1.00 E-02	4,796
9.00 E-02	28,165	5.00 E-02	17,182	1.28 E-02	11,004	2.00 E-02	9,962	2.00 E-02	7,662	1.00 E-02	5,388	1.54 E-02	5,000
1.00 E-01	28,302	6.00 E-02	17,746	2.00 E-02	12,099	3.00 E-02	10,548	3.00 E-02	8,041	2.00 E-02	5,813	2.00 E-02	5,127
...	...	7.00 E-02	18,215	3.00 E-02	13,068	4.00 E-02	10,954	4.00 E-02	8,302	3.00 E-02	6,056	3.00 E-02	5,326
...	...	8.00 E-02	18,614	4.00 E-02	13,724	5.00 E-02	11,259	5.00 E-02	8,497	4.00 E-02	6,222	4.00 E-02	5,464
...	...	9.00 E-02	18,959	5.00 E-02	14,205	6.00 E-02	11,499	6.00 E-02	8,650	5.00 E-02	6,345	5.00 E-02	5,566
...	...	1.00 E-01	19,261	6.00 E-02	14,580	7.00 E-02	11,693	7.00 E-02	8,774	6.00 E-02	6,442	6.00 E-02	5,645
...	7.00 E-02	14,887	8.00 E-02	11,855	8.00 E-02	8,877	7.00 E-02	6,519	7.00 E-02	5,708
...	8.00 E-02	15,145	9.00 E-02	11,991	9.00 E-02	8,964	8.00 E-02	6,584	8.00 E-02	5,760

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**Table II-5
Tabular Values of A Versus S_c at 1,200°F (Cont'd)**

Hot Tensile		10 hr		100 hr		1,000 hr		10,000 hr		100,000 hr		300,000 hr	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
...	9.00 E-02	15,370	1.00 E-01	12,108	1.00 E-01	9,038	9.00 E-02	6,638	9.00 E-02	5,803
...	1.00 E-01	15,569	...	...	...	...	1.00 E-01	6,685	1.00 E-01	5,841

Table II-5.1
Equation of A Versus S_c at 1,200°F

Corresponding Variables in Equation [Note (1)]	Hot Tensile		
	$A < 0.000342$	$0.000342 < A < 0.00585$	$0.00585 < A < 0.1$
<i>a</i>	<i>AE</i>	8,100	12,457.938
<i>b</i>	0	-3,260.2561	249.81876
<i>c</i>	0	-13,843,026	6,466,029
<i>d</i>	0	-2,297,378.1	4,726.8606
<i>e</i>	0	-5.5006489 E+10	1.4140819 E+08
<i>e</i>	0	17,904,079.00	0
Corresponding Variables in Equation [Note (1)]	10 hr		
	$A < 0.0000884$	$0.0000884 < A < 0.00894$	$0.00894 < A < 0.1$
<i>a</i>	<i>AE</i>	-190	7,817.0975
<i>b</i>	0	4,703.564	94.991391
<i>c</i>	0	34,418,600	1,512,340.8
<i>d</i>	0	556,197.69	877.80329
<i>e</i>	0	9.291228 E+09	2.122387 E+07
Corresponding Variables in Equation [Note (1)]	100 hr		
	$A < 0.000043$	$0.000043 < A < 0.0128$	$0.0128 < A < 0.1$
<i>a</i>	<i>AE</i>	-570	7,000
<i>b</i>	0	7,324.9089	58.082716
<i>c</i>	0	43,484,968	951,695.33
<i>d</i>	0	1,333,230.5	-24.590471
<i>e</i>	0	1.763429 E+10	0
Corresponding Variables in Equation [Note (1)]	1,000 hr		
	$A < 0.000043$	$0.000043 < A < 0.1$	
<i>a</i>	<i>AE</i>	-500	
<i>b</i>	0	7,544.3848	
<i>c</i>	0	42,054,198	
<i>d</i>	0	1,828,837.5	
<i>e</i>	0	1.740295E+10	
<i>f</i>	0	33,787,651	
<i>g</i>	0	4.614434 E+11	
<i>h</i>	0	-1,460,099.5	
Corresponding Variables in Equation [Note (1)]	10,000 hr		
	$A < 0.0000431$	$0.0000431 < A < 0.1$	
<i>a</i>	<i>AE</i>	-600	
<i>b</i>	0	8,971.9687	
<i>c</i>	0	45,912,539	
<i>d</i>	0	1,631,820.9	
<i>e</i>	0	1.236319E +10	
<i>f</i>	0	27,426,260	
<i>g</i>	0	2.752643 E+11	
Corresponding Variables in Equation [Note (1)]	100,000 hr		
	$A < 0.0000431$	$0.0000431 < A < 0.00517$	$0.00517 < A < 0.1$
<i>a</i>	<i>AE</i>	-1500	4,056.906
<i>b</i>	0	19,240.074	185.68946
<i>c</i>	0	76,754,201	1,073,409.9
<i>d</i>	0	4,414,689.6	3,151.3673
<i>e</i>	0	2.56 E+10	2.300751 E+07
<i>f</i>	0	-16,737,525	0

Table II-5.1
Equation of A Versus S_c at 1,200°F (Cont'd)

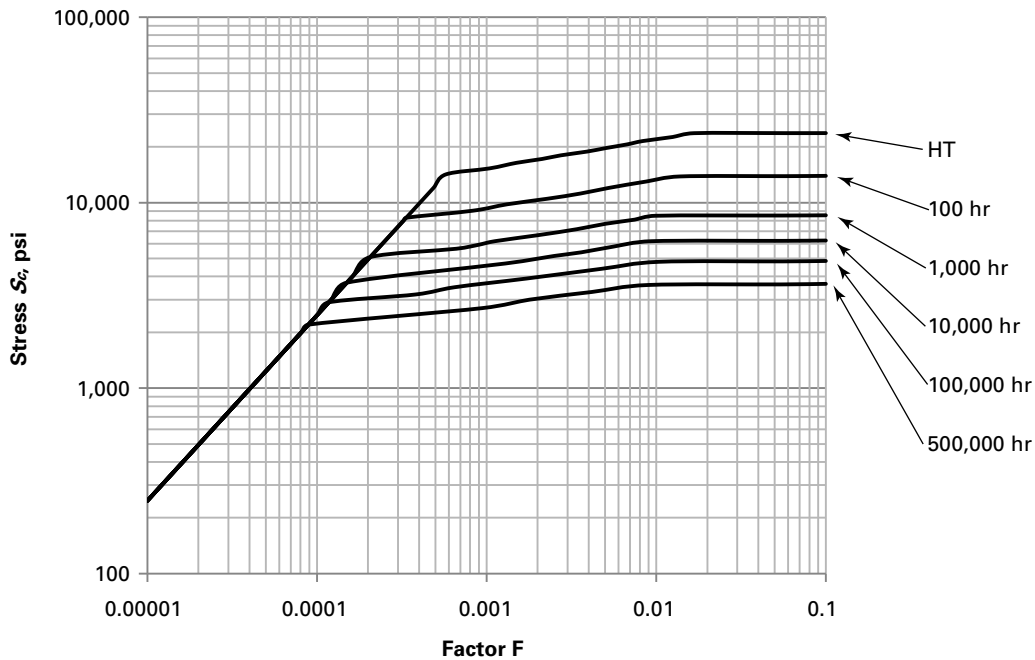
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	A < 0.0000431	0.0000431 < A < 0.0154	0.0154 < A < 0.1
a	AE	-1,500	4,242.3335
b	0	20,878.68	41.574097
c	0	78,628,243	257,062.1
d	0	2,520,802.6	-2.9844765
e	0	1.430431 E+10	0

GENERAL NOTE: E = 23.3 E+06 psi

NOTE: (1) The following equation applies to this table:

$$S_c = \frac{a + cA + eA^2 + gA^3}{1 + bA + dA^2 + fA^3 + hA^4}$$

Figure II-6
External Pressure Chart at 700°F to 1,000°F for 2.25Cr-1Mo Annealed Steel



GENERAL NOTES:

(a) E = 24.7 E+06 psi

(b) See also [Table II-6](#) and [Table II-6.1](#).

Table II-6
Tabular Values of A Versus S_c at 700°F to 1,000°F

Hot Tensile		100 hr		1,000 hr		10,000 hr		100,000 hr		500,000 hr	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
1.00 E-05	247	1.00 E-05	247	1.00 E-05	247	1.00 E-05	247	1.00 E-05	247	1.00 E-05	247
5.75 E-04	14,203	3.36 E-04	8,299	2.06 E-04	5,088	1.50 E-04	3,705	1.17 E-04	2,900	8.91 E-05	2,201
6.00 E-04	14,284	4.00 E-04	8,404	3.00 E-04	5,225	2.00 E-04	3,772	2.00 E-04	3,028	9.00 E-05	2,207
7.00 E-04	14,519	5.00 E-04	8,555	4.00 E-04	5,360	3.00 E-04	3,883	3.00 E-04	3,143	1.00 E-04	2,214
8.00 E-04	14,744	6.00 E-04	8,699	5.00 E-04	5,485	4.00 E-04	3,985	4.00 E-04	3,243	2.00 E-04	2,281
9.00 E-04	14,959	7.00 E-04	8,837	6.00 E-04	5,601	5.00 E-04	4,079	5.00 E-04	3,331	3.00 E-04	2,342
1.00 E-03	15,165	8.00 E-04	8,969	7.00 E-04	5,709	6.00 E-04	4,166	6.00 E-04	3,409	4.00 E-04	2,400
2.00 E-03	16,834	9.00 E-04	9,095	8.00 E-04	5,810	7.00 E-04	4,248	7.00 E-04	3,478	5.00 E-04	2,454
3.00 E-03	18,022	1.00 E-03	9,216	9.00 E-04	5,904	8.00 E-04	4,324	8.00 E-04	3,540	6.00 E-04	2,504
4.00 E-03	18,923	2.00 E-03	10,201	1.00 E-03	5,992	9.00 E-04	4,395	9.00 E-04	3,597	7.00 E-04	2,552
5.00 E-03	19,638	3.00 E-03	10,907	2.00 E-03	6,653	1.00 E-03	4,462	1.00 E-03	3,648	8.00 E-04	2,596
6.00 E-03	20,227	4.00 E-03	11,446	3.00 E-03	7,080	2.00 E-03	4,961	2.00 E-03	3,991	9.00 E-04	2,638
7.00 E-03	20,726	5.00 E-03	11,875	4.00 E-03	7,394	3.00 E-03	5,280	3.00 E-03	4,185	1.00 E-03	2,678
8.00 E-03	21,159	6.00 E-03	12,229	5.00 E-03	7,643	4.00 E-03	5,509	4.00 E-03	4,318	2.00 E-03	2,978
9.00 E-03	21,542	7.00 E-03	12,530	6.00 E-03	7,852	5.00 E-03	5,686	5.00 E-03	4,421	3.00 E-03	3,170
1.00 E-02	21,886	8.00 E-03	12,791	7.00 E-03	8,036	6.00 E-03	5,830	6.00 E-03	4,507	4.00 E-03	3,301
1.67 E-02	23,642	9.00 E-03	13,022	8.00 E-03	8,203	7.00 E-03	5,953	7.00 E-03	4,582	5.00 E-03	3,396
2.00 E-02	23,701	1.00 E-02	13,230	9.00 E-03	8,358	8.00 E-03	6,062	8.00 E-03	4,651	6.00 E-03	3,467
3.00 E-02	23,703	1.38 E-02	13,881	9.88 E-03	8,487	9.00 E-03	6,160	9.00 E-03	4,715	7.00 E-03	3,521
4.00 E-02	23,706	2.00 E-02	13,883	1.00 E-02	8,499	9.39 E-03	6,196	1.00 E-02	4,776	8.00 E-03	3,564
5.00 E-02	23,708	3.00 E-02	13,895	2.00 E-02	8,506	1.00 E-02	6,200	1.04 E-02	4,800	9.00 E-03	3,599
6.00 E-02	23,710	4.00 E-02	13,906	3.00 E-02	8,511	2.00 E-02	6,205	2.00 E-02	4,805	1.00 E-02	3,601
7.00 E-02	23,713	5.00 E-02	13,918	4.00 E-02	8,517	3.00 E-02	6,206	3.00 E-02	4,811	2.00 E-02	3,606
8.00 E-02	23,715	6.00 E-02	13,930	5.00 E-02	8,522	4.00 E-02	6,211	4.00 E-02	4,817	3.00 E-02	3,612
9.00 E-02	23,718	7.00 E-02	13,941	6.00 E-02	8,528	5.00 E-02	6,217	5.00 E-02	4,822	4.00 E-02	3,617
1.00 E-01	23,720	8.00 E-02	13,953	7.00 E-02	8,533	6.00 E-02	6,222	6.00 E-02	4,828	5.00 E-02	3,623
...	...	9.00 E-02	13,964	8.00 E-02	8,539	7.00 E-02	6,228	7.00 E-02	4,833	6.00 E-02	3,628
...	...	1.00 E-01	13,976	9.00 E-02	8,544	8.00 E-02	6,233	8.00 E-02	4,839	7.00 E-02	3,634
...	1.00 E-01	8,550	9.00 E-02	6,239	9.00 E-02	4,844	8.00 E-02	3,639
...	1.00 E-01	6,244	1.00 E-01	4,850	9.00 E-02	3,645
...	1.00 E-01	3,650

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Table II-6.1
Equation of A Versus S_c at 700°F to 1,000°F

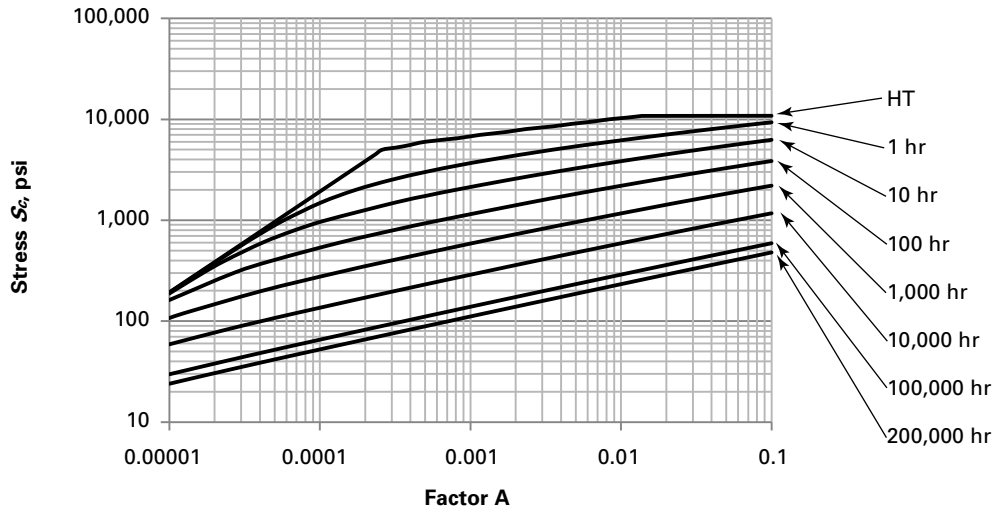
Corresponding Variables in Equation [Note (1)]	Hot Tensile		
	A < 0.000575	0.000575 < A < 0.0167	0.0167 < A < 0.1
a	AE	12,600	23,696.019
b	0	283.09278	0
c	0	6,838,889	240.09039
d	0	-1,304.9604	0
Corresponding Variables in Equation [Note (1)]	100 hr		
	A < 0.000336	0.000336 < A < 0.0138	0.0138 < A < 0.1
a	AE	7,720	13,860
b	0	273.26084	0
c	0	4,002,567.9	1,160.0907
d	0	-1,237.9837	0
Corresponding Variables in Equation [Note (1)]	1,000 hr		
	A < 0.000206	0.000206 < A < 0.00988	0.00988 < A < 0.1
a	AE	4,740	8,494.5073
b	0	502.28859	0
c	0	4,232,823.1	554.81547
d	0	-4,882.9385	0
Corresponding Variables in Equation [Note (1)]	10,000 hr		
	A < 0.00015	0.00015 < A < 0.00939	0.00939 < A < 0.1
a	AE	3,520	6,200
b	0	479.46279	0
c	0	3,067,033.9	551.80714
d	0	-3,239.5585	0
Corresponding Variables in Equation [Note (1)]	100,000 hr		
	A < 0.000117	0.000117 < A < 0.0104	0.0104 < A < 0.1
a	AE	2,735.8136	4,794.1964
b	0	925.96714	0
c	0	4,262,250.1	558.03571
d	0	-7,631.3686	0
Corresponding Variables in Equation [Note (1)]	500,000 hr		
	A < 0.0000891	0.0000891 < A < 0.009	0.009 < A < 0.1
a	AE	2,142.9941	3,595.0548
b	0	381.17794	0
c	0	1,557,493.3	549.45055
d	0	742.7192	0

GENERAL NOTE: E = 24.7 E+06 psi

NOTE: (1) The following equation applies to this table:

$$S_c = \frac{a + cA}{1 + bA + dA^2}$$

Figure II-7
253MA Stainless Steel at 1,200°F to 1,650°F



GENERAL NOTE: (a) See also [Table II-7](#) and [Table II-7.1](#).

**Table II-7
Tabular Values of A Versus S_c at 1,200°F to 1,650°F**

Hot Tensile		1 hr		10 hr		100 hr		1,000 hr		10,000 hr		100,000 hr		200,000 hr	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
1.00 E-05	193	1.00 E-05	192	1.00 E-05	188	1.00 E-05	162	1.00 E-05	107	1.00 E-05	61	1.00 E-05	30	1.00 E-05	24
2.00 E-05	385	2.00 E-05	387	2.00 E-05	347	2.00 E-05	244	2.00 E-05	141	2.00 E-05	76	2.00 E-05	38	2.00 E-05	30
3.00 E-05	577	3.00 E-05	570	3.00 E-05	473	3.00 E-05	306	3.00 E-05	168	3.00 E-05	88	3.00 E-05	44	3.00 E-05	35
4.00 E-05	769	4.00 E-05	738	4.00 E-05	577	4.00 E-05	356	4.00 E-05	191	4.00 E-05	98	4.00 E-05	48	4.00 E-05	39
5.00 E-05	962	5.00 E-05	892	5.00 E-05	664	5.00 E-05	397	5.00 E-05	210	5.00 E-05	107	5.00 E-05	52	5.00 E-05	42
6.00 E-05	1,154	6.00 E-05	1,032	6.00 E-05	739	6.00 E-05	433	6.00 E-05	226	6.00 E-05	115	6.00 E-05	55	6.00 E-05	44
7.00 E-05	1,346	7.00 E-05	1,159	7.00 E-05	804	7.00 E-05	463	7.00 E-05	241	7.00 E-05	121	7.00 E-05	58	7.00 E-05	47
8.00 E-05	1,538	8.00 E-05	1,276	8.00 E-05	861	8.00 E-05	491	8.00 E-05	254	8.00 E-05	127	8.00 E-05	61	8.00 E-05	49
9.00 E-05	1,731	9.00 E-05	1,382	9.00 E-05	913	9.00 E-05	515	9.00 E-05	265	9.00 E-05	133	9.00 E-05	63	9.00 E-05	51
1.00 E-04	1,923	1.00 E-04	1,479	1.00 E-04	959	1.00 E-04	537	1.00 E-04	276	1.00 E-04	138	1.00 E-04	66	1.00 E-04	53
2.00 E-04	3,846	2.00 E-04	2,140	2.00 E-04	1,276	2.00 E-04	689	2.00 E-04	350	2.00 E-04	173	2.00 E-04	82	2.00 E-04	66
2.60 E-04	5,000	3.00 E-04	2,519	3.00 E-04	1,471	3.00 E-04	788	3.00 E-04	399	3.00 E-04	196	3.00 E-04	94	3.00 E-04	75
3.00 E-04	5,309	4.00 E-04	2,787	4.00 E-04	1,617	4.00 E-04	865	4.00 E-04	438	4.00 E-04	214	4.00 E-04	103	4.00 E-04	83
4.00 E-04	5,534	4.98 E-04	3,000	5.00 E-04	1,736	5.00 E-04	929	5.00 E-04	470	5.00 E-04	230	5.00 E-04	111	5.00 E-04	89
5.00 E-04	5,740	5.00 E-04	3,012	6.00 E-04	1,837	6.00 E-04	985	6.00 E-04	498	6.00 E-04	244	6.00 E-04	118	6.00 E-04	94
6.00 E-04	5,931	6.00 E-04	3,171	7.00 E-04	1,925	7.00 E-04	1,034	7.00 E-04	524	7.00 E-04	256	7.00 E-04	124	7.00 E-04	99
7.00 E-04	6,108	7.00 E-04	3,314	8.00 E-04	2,003	8.00 E-04	1,078	8.00 E-04	547	8.00 E-04	268	8.00 E-04	129	8.00 E-04	104
8.00 E-04	6,272	8.00 E-04	3,443	9.00 E-04	2,073	9.00 E-04	1,118	9.00 E-04	568	9.00 E-04	278	9.00 E-04	134	9.00 E-04	108
9.00 E-04	6,425	9.00 E-04	3,561	1.00 E-03	2,137	1.00 E-03	1,155	1.00 E-03	587	1.00 E-03	288	1.00 E-03	138	1.00 E-03	111
1.00 E-03	6,569	1.00 E-03	3,669	2.00 E-03	2,581	2.00 E-03	1,413	2.00 E-03	728	2.00 E-03	360	2.00 E-03	172	1.26 E-03	120
2.00 E-03	7,622	2.00 E-03	4,404	3.00 E-03	2,866	3.00 E-03	1,581	3.00 E-03	820	3.00 E-03	408	3.00 E-03	197	2.00 E-03	133
3.00 E-03	8,281	3.00 E-03	4,832	3.57 E-03	3,000	4.00 E-03	1,713	4.00 E-03	892	4.00 E-03	444	3.11 E-03	200	3.00 E-03	148
4.00 E-03	8,746	4.00 E-03	5,133	4.00 E-03	3,078	4.30 E-03	1,750	5.00 E-03	953	5.00 E-03	473	4.00 E-03	211	4.00 E-03	162
5.00 E-03	9,101	5.00 E-03	5,370	5.00 E-03	3,242	5.00 E-03	1,823	5.83 E-03	1,000	6.00 E-03	499	5.00 E-03	223	5.00 E-03	175
6.00 E-03	9,389	6.00 E-03	5,571	6.00 E-03	3,387	6.00 E-03	1,913	6.00 E-03	1,008	7.00 E-03	523	6.00 E-03	234	6.00 E-03	187
7.00 E-03	9,633	7.00 E-03	5,750	7.00 E-03	3,515	7.00 E-03	1,994	7.00 E-03	1,053	8.00 E-03	546	7.00 E-03	244	7.00 E-03	198
8.00 E-03	9,847	8.00 E-03	5,917	8.00 E-03	3,631	8.00 E-03	2,067	8.00 E-03	1,094	9.00 E-03	568	8.00 E-03	255	8.00 E-03	208
9.00 E-03	10,039	8.52 E-03	6,000	9.00 E-03	3,736	9.00 E-03	2,133	9.00 E-03	1,132	1.00 E-02	589	9.00 E-03	264	9.00 E-03	217
1.00 E-02	10,216	9.00 E-03	6,067	1.00 E-02	3,831	1.00 E-02	2,193	1.00 E-02	1,167	1.05 E-02	600	1.00 E-02	274	1.00 E-02	226
1.37 E-02	10,787	1.00 E-02	6,182	2.00 E-02	4,494	2.00 E-02	2,624	2.00 E-02	1,425	2.00 E-02	716	2.00 E-02	352	2.00 E-02	290
2.00 E-02	10,803	2.00 E-02	7,044	3.00 E-02	4,904	3.00 E-02	2,901	3.00 E-02	1,595	3.00 E-02	813	3.00 E-02	410	3.00 E-02	330
3.00 E-02	10,806	3.00 E-02	7,603	4.00 E-02	5,207	4.00 E-02	3,110	4.00 E-02	1,725	4.00 E-02	892	4.00 E-02	454	4.00 E-02	361
4.00 E-02	10,810	4.00 E-02	8,007	5.00 E-02	5,450	5.00 E-02	3,280	5.00 E-02	1,832	5.00 E-02	958	5.00 E-02	489	5.00 E-02	385
5.00 E-02	10,813	5.00 E-02	8,322	6.00 E-02	5,656	6.00 E-02	3,425	6.00 E-02	1,924	6.00 E-02	1,014	6.00 E-02	517	6.00 E-02	407

Table II-7
Tabular Values of A Versus S_c at 1,200°F to 1,650°F (Cont'd)

Hot Tensile		1 hr		10 hr		100 hr		1,000 hr		10,000 hr		100,000 hr		200,000 hr	
A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi	A	S _c psi
6.00 E-02	10,817	6.00 E-02	8,581	7.00 E-02	5,834	7.00 E-02	3,550	7.00 E-02	2,005	7.00 E-02	1,061	7.00 E-02	540	7.00 E-02	426
7.00 E-02	10,820	7.00 E-02	8,803	8.00 E-02	5,991	8.00 E-02	3,662	8.00 E-02	2,077	8.00 E-02	1,102	8.00 E-02	559	8.00 E-02	444
8.00 E-02	10,823	8.00 E-02	8,999	9.00 E-02	6,132	9.00 E-02	3,762	9.00 E-02	2,142	9.00 E-02	1,137	9.00 E-02	576	9.00 E-02	462
9.00 E-02	10,827	9.00 E-02	9,177	1.00 E-01	6,259	1.00 E-01	3,853	1.00 E-01	2,200	1.00 E-01	1,169	1.00 E-01	590	1.00 E-01	479
1.00 E-01	10,830	1.00 E-01	9,342	...	...	...	...	...	...	...	...	...	...	...	...

Table II-7.1
Equation of A Versus S_c at 1,200°F to 1,650°F

Corresponding Variables in Equation [Note (1)]	Hot Tensile		
	1 E-05 < A < 0.00026	0.00026 < A < 0.0137	0.0137 < A < 0.1
<i>a</i>	0.59597055	4,500	10,796.376
<i>b</i>	-6.2383167	514.63261	0
<i>c</i>	19,214,406	5,423,194.7	336.25171
<i>d</i>	13,360.491	-3,970.8543	0

Corresponding Variables in Equation [Note (1)]	1 hr		
	1 E-05 < A < 0.000498	0.000498 < A < 0.00852	0.00852 < A < 0.1
<i>a</i>	-12.00	1,835.7091	4,591.6251
<i>b</i>	17,336.741	834.43502	45.646867
<i>c</i>	20,274,034	4,847,478.8	438,886.74
<i>d</i>	1.12 E+08	-12,674.375	-37.500831
<i>e</i>	3.63 E+11	0	0
<i>f</i>	-3.19 E+10	0	0

Corresponding Variables in Equation [Note (1)]	10 hr		
	1 E-05 < A < 0.00357	0.00357 < A < 0.1	
<i>a</i>	-20.00	2,085.00	
<i>b</i>	17,909.152	125.803	
<i>c</i>	23,755,443	617,777.08	
<i>d</i>	13,990,058	729.50851	
<i>e</i>	4.56 E+10	6,679,716.6	
<i>f</i>	-4.69 E+08	0	

Corresponding Variables in Equation [Note (1)]	100 hr		
	1 E-05 < A < 0.0043	0.0043 < A < 0.1	
<i>a</i>	52.00	1,089.9066	
<i>b</i>	21,531.635	145.72658	
<i>c</i>	14,303,795	389,619.09	
<i>d</i>	16,113,004	1,348.4801	
<i>e</i>	2.96 E+10	6,977,939.1	
<i>f</i>	-5.43 E+08	-552.85242	

Corresponding Variables in Equation [Note (1)]	1,000 hr		
	1 E-05 < A < 0.00583	0.00583 < A < 0.1	
<i>a</i>	64.00	609.04204	
<i>b</i>	17,174.104	88.891517	
<i>c</i>	6,123,479.9	150,412.17	
<i>d</i>	9,649,111.6	218.42662	
<i>e</i>	9.99 E+09	1,173,137.9	
<i>f</i>	-2.72 E+08	372.80851	

Corresponding Variables in Equation [Note (1)]	10,000 hr		
	1 E-05 < A < 0.0105	0.0105 < A < 0.1	
<i>a</i>	41.100542	435.00	
<i>b</i>	16,309.263	14.829784	
<i>c</i>	2,900,078.8	24,672.354	
<i>d</i>	7,592,852.1	0	
<i>e</i>	4.19 E+09	0	
<i>f</i>	-1.63 E+08	0	

Table II-7.1
Equation of A Versus S_c at 1,200°F to 1,650°F (Cont'd)

Corresponding Variables in Equation [Note (1)]	100,000 hr	
	1 E-05 < A < 0.00311	0.00311 < A < 0.1
<i>a</i>	18.894906	160.00
<i>b</i>	2.886437 E+04	22.430776
<i>c</i>	1.92 E+06	17,529.347
<i>d</i>	3.48 E+07	0
<i>e</i>	6.67 E+09	0
<i>f</i>	-2.50 E+09	0
Corresponding Variables in Equation [Note (1)]	200,000 hr	
	1 E-05 < A < 0.00126	0.00126 < A < 0.1
<i>a</i>	14.799303	97.00
<i>b</i>	33,280.766	57.120436
<i>c</i>	1,681,286.4	2,5474.34
<i>d</i>	49,879,803	-119.29564
<i>e</i>	7.05 E+09	0
<i>f</i>	-5.54 E+09	0

NOTE: (1) The following equation applies to this table:

$$S_c = \frac{a + cA + eA^2}{1 + bA + dA^2 + fA^3}$$

MANDATORY APPENDIX III

CONSTANTS A_i AND B_i AND FACTORS m_2 AND ε'_p

Table III-1 lists values of constants A_i and B_i in Mandatory Appendix I, Eqs. (I-7), (I-8), (I-28), and (I-29) (ksi, °F). Table III-2 lists temperature limits for Factors m_2 and ε'_p .

Table III-1
Constants A_i and B_i

Material	Notes	Strain Rate Parameter, $\dot{\varepsilon}_{co}$		Omega Parameter, Ω	
Carbon Steel	See [Note (1)] and [Note (2)]	A_0	-16.300	B_0	-1.000
		A_1	38,060.000	B_1	3,060.000
		A_2	-9,165.000	B_2	135.000
		A_3	1,200.000	B_3	-760.000
		A_4	-600.000	B_4	247.000
C-0.5Mo	See [Note (1)] and [Note (2)]	A_0	-19.500	B_0	-1.300
		A_1	61,000.000	B_1	4,500.000
		A_2	-49,000.000	B_2	2,000.000
		A_3	33,000.000	B_3	-4,500.000
		A_4	-8,000.000	B_4	2,000.000
1.25Cr-0.5Mo — N&T	- See [Note (1)] and [Note (2)] - Use only below 1,000°F and stresses above 10 ksi	A_0	-23.350	B_0	-4.400
		A_1	62,070.000	B_1	14,510.000
		A_2	-47,520.000	B_2	-24,671.000
		A_3	43,800.000	B_3	29,384.000
		A_4	-14,790.000	B_4	-10,630.000
2.25Cr-1Mo — N&T	- See [Note (1)] and [Note (2)] - Use only below 950°F and stresses above 15 ksi	A_0	-21.560	B_0	-1.120
		A_1	55,518.000	B_1	5,032.000
		A_2	-10,910.000	B_2	-360.000
		A_3	-1,705.000	B_3	-2,320.000
		A_4	0.000	B_4	1,210.000
2.25Cr-1Mo — Annealed	See [Note (1)] and [Note (2)]	A_0	-21.860	B_0	-1.850
		A_1	51,635.000	B_1	7,205.000
		A_2	-7,330.000	B_2	-2,436.000
		A_3	-2,577.000	B_3	0.000
		A_4	0.000	B_4	0.000
2.25Cr-1Mo — Q&T	- See [Note (1)] and [Note (2)] - Use only below 950°F and stresses above 15 ksi	A_0	-21.560	B_0	-1.120
		A_1	55,518.000	B_1	5,032.000
		A_2	-10,910.000	B_2	-360.000
		A_3	-1,705.000	B_3	-2,320.000
		A_4	0.000	B_4	1,210.000
2.25Cr-1Mo — V	- See [Note (1)] and [Note (2)] - Use only below 950°F and stresses above 20 ksi	A_0	-25.000	B_0	-2.520
		A_1	52,189.480	B_1	5,809.590
		A_2	-771.970	B_2	-454.660
		A_3	-2,093.730	B_3	-79.570
		A_4	-1,042.530	B_4	227.570

Table III-1
Constants A_i and B_i (Cont'd)

Material	Notes	Strain Rate Parameter, $\dot{\epsilon}_{co}$		Omega Parameter, Ω	
5Cr-0.5Mo	See [Note (1)] and [Note (2)]	A_0	-22.400	B_0	-1.400
		A_1	51,635.000	B_1	5,035.000
		A_2	-7,330.000	B_2	-1,330.000
		A_3	-2,577.000	B_3	423.000
		A_4	0.000	B_4	0.000
9Cr-1Mo	See [Note (1)] and [Note (2)]	A_0	-22.550	B_0	-2.050
		A_1	51,297.200	B_1	6,235.000
		A_2	-5,430.700	B_2	170.000
		A_3	-4,749.000	B_3	-3,100.000
		A_4	1,400.600	B_4	1,625.000
9Cr-1Mo — V	See [Note (1)] and [Note (2)]	A_0	-34.000	B_0	-2.000
		A_1	73,201.800	B_1	7,200.000
		A_2	-2,709.000	B_2	-1,500.000
		A_3	-4,673.000	B_3	0.000
		A_4	-569.000	B_4	0.000
12Cr	See [Note (1)] and [Note (2)]	A_0	-30.290	B_0	-3.298
		A_1	67,110.000	B_1	6,508.000
		A_2	-21,093.000	B_2	3,016.000
		A_3	14,556.000	B_3	-2,784.000
		A_4	-5,884.000	B_4	480.000
Type 304 and 304H	See [Note (1)] and [Note (2)]	A_0	-19.170	B_0	-3.400
		A_1	53,762.400	B_1	11,250.000
		A_2	-13,442.400	B_2	-5,635.800
		A_3	3,162.600	B_3	3,380.400
		A_4	-1,685.200	B_4	-993.600
Type 316 and 316H	See [Note (1)] and [Note (2)]	A_0	-18.900	B_0	-4.163
		A_1	57,190.000	B_1	17,104.760
		A_2	-18,060.000	B_2	-12,620.000
		A_3	2,842.213	B_3	3,949.151
		A_4	200.200	B_4	400.000
Type 321	See [Note (1)] and [Note (2)]	A_0	-19.000	B_0	-3.400
		A_1	49,425.000	B_1	10,625.000
		A_2	-7,417.000	B_2	-3,217.000
		A_3	1,240.000	B_3	1,640.000
		A_4	-1,290.000	B_4	-490.000
Type 321H	See [Note (1)] and [Note (2)]	A_0	-18.400	B_0	-3.400
		A_1	49,425.000	B_1	10,625.000
		A_2	-7,417.000	B_2	-3,217.000
		A_3	1,240.000	B_3	1,640.000
		A_4	-1,290.000	B_4	-490.000
Type 347	See [Note (1)] and [Note (2)]	A_0	-18.300	B_0	-3.500
		A_1	47,140.000	B_1	10,000.000
		A_2	-5,434.000	B_2	-800.000
		A_3	500.000	B_3	-100.000
		A_4	-1,128.000	B_4	100.000

**Table III-1
Constants A_i and B_i (Cont'd)**

Material	Notes	Strain Rate Parameter, $\dot{\epsilon}_{co}$		Omega Parameter, Ω	
Type 347H	See [Note (1)] and [Note (2)]	A_0	-17.700	B_0	-3.650
		A_1	47,140.000	B_1	10,000.000
		A_2	-5,434.000	B_2	-800.000
		A_3	500.000	B_3	-100.000
		A_4	-1,128.000	B_4	100.000
Type 347LN	See [Note (1)] and [Note (2)]	A_0	-16.8066	B_0	-0.400
		A_1	106,772.500	B_1	64,882.200
		A_2	-144,824.000	B_2	-139,199.000
		A_3	100,432.000	B_3	101,073.200
		A_4	-24,013.300	B_4	-23,843.700
Alloy 800	See [Note (1)] and [Note (2)]	A_0	-19.400	B_0	-3.600
		A_1	55,548.000	B_1	11,250.000
		A_2	-15,877.000	B_2	-5,635.000
		A_3	3,380.000	B_3	3,380.000
		A_4	-993.000	B_4	-993.000
Alloy 800H	See [Note (1)] and [Note (2)]	A_0	-18.800	B_0	-3.600
		A_1	55,548.000	B_1	11,250.000
		A_2	-15,877.000	B_2	-5,635.000
		A_3	3,380.000	B_3	3,380.000
		A_4	-993.000	B_4	-993.000
Alloy 800HT	See [Note (1)] and [Note (2)]	A_0	-20.250	B_0	-3.400
		A_1	59,415.000	B_1	11,250.000
		A_2	-13,677.000	B_2	-5,635.000
		A_3	-1,009.000	B_3	3,380.000
		A_4	625.000	B_4	-993.000

GENERAL NOTE: This table is adapted from API 579-1/ASME FFS-1 (June 2016), Table 10B.1.

NOTES:

- (1) Coefficients in this table are estimates of the typical material behavior.
- (2) The coefficients in this table are intended to describe material behavior in the range of the ASME Code design allowable stress for a given material at a specified temperature. These coefficients may be used to estimate the stress relaxation resulting from creep over a similar stress range.

**Table III-2
Factors m_2 and ϵ'_p for Mandatory Appendix I, Eqs. (I-15), (I-20), and (I-21)**

Material	Temperature Limit, °F	Factor m_2 [Note (1)]	Factor ϵ'_p
Ferrous steel	900	0.60(1.00 - R)	2.0 E-5
Stainless steel and nickel based alloys	900	0.75(1.00 - R)	2.0 E-5
Duplex stainless steel	900	0.70(1.00 - R)	2.0 E-5

NOTE: (1) R is the ratio of the engineering yield stress to engineering tensile stress evaluated at the assessment temperature.

Case 2965

Alternative Rules for the Design of U-Tube Tubesheets, Configurations a and e

Section VIII, Division 1; Section VIII, Division 2

Approval Date: July 24, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For Section VIII, Divisions 1 and 2 U-tube tubesheets, configurations a and e not meeting the minimum channel length requirement, may the U-tube tubesheet be designed to a procedure other than the procedure given in Section VIII, Division 1, UHX-12 and Section VIII, Division 2, 4.18.7?

Reply: It is the opinion of the Committee that Section VIII, Divisions 1 and 2 U-tube tubesheets, configurations a and e not meeting the minimum channel length requirement, may be designed using the following rules in lieu of those given in Section VIII, Division 1, UHX-12 and Section VIII, Division 2, 4.18.7.

(a) Nomenclature

$t_{c,\min}$ = channel minimum required thickness
 t_r = channel reference thickness; the value of t_r shall be $t_{c,\min} \leq t_r \leq t_c$

See Section VIII, Division 1, UHX-12.3 and Section VIII, Division 2, 4.18.15 for other applicable nomenclature.

(b) *Alternative Rules.* With reference to Section VIII, Division 1, UHX-12.5 and Section VIII, Division 2, 4.18.7.4, the alternative rules are as follows:

- (1) Perform Steps 1 through 3.
 - (2) Replace t_c with t_r in Step 4.
 - (3) Perform Step 5 to Step 9.
 - (4) In Step 10 replace t_c with t_r . The minimum length of channel with uniform thickness shall be equal to $1.8(D_c t_r)^{0.5}$.
 - (5) Step 11, option 2: replace t_c with t_r as required.
 - (6) Complete the calculation until acceptance criteria are satisfied.
 - (7) Repeat the calculations from Step 1 to Step 11 with the value t_c ; the minimum length of channel with uniform thickness $1.8(D_c t_c)^{0.5}$ is not required to be met.
 - (8) Verify the tubesheet bending stress. If $s \leq 2S$, the design is complete. Otherwise increase tubesheet thickness h and return to Step 1.
- (c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2967

Use of Stud Welding for Fitting Attachment of Part HG Boilers Fabricated by Welding

Section IV

Approval Date: August 28, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may arc-stud welding and resistance-stud welding, as defined in Nonmandatory Appendix E, E-101, where the pressure exerts a tensile load on the studs, be used for the mechanical attachment of fittings used to secure piping to the front plate of a boiler fabricated by welding?

Reply: It is the opinion of the Committee that arc-stud welding and resistance-stud welding, as defined in Nonmandatory Appendix E, E-101, where the pressure exerts a tensile load on the studs, may be used for the mechanical attachment of fittings used to secure piping to the front plate of a boiler fabricated by welding, provided the following requirements are met:

(a) Mechanically attached internally or externally threaded fittings shall be limited to a maximum NPS 3 (DN 80) and shall be secured by a minimum of four studs.

(b) Daily production weld tests shall be as per HW-820.4.

(c) Studs attached by stud welding shall not be in direct contact with product of combustion or flue gases.

(d) The minimum stud size used shall be not less than $\frac{1}{4}$ in. (6 mm) nominal diameter, and the maximum size shall not exceed $\frac{7}{8}$ in. (22 mm) nominal diameter.

(e) The type of the stud shall be limited to round internally or externally threaded studs.

(f) Base metal shall be of ferrous material specification as permitted by Section IV, and the base metal must be thick enough to prevent burn through.

(g) Stud material for arc-stud welding and resistance-stud welding of carbon steel shall be low carbon steel of an acceptable material in Section IV with a carbon maximum of 0.27% and a minimum tensile strength of 60,000 psi (400 MPa).

(h) The maximum spacing of studs shall not exceed 12 times the nominal diameter of the stud.

(i) The maximum allowable stress for the stud shall be 7,800 psi (54 MPa) based on the smallest cross sectional area (i.e., the root of the thread).

(j) Gaskets for internally or externally threaded fittings mechanically attached using arc-stud welding or resistance-stud welding may be of the flat or ring type, made of a material suitable for service at a minimum of 250°F (120°C). When ring-type gaskets are employed, a suitable recess shall be provided in the fitting to accommodate the gasket.

(k) The maximum allowable working pressure for a vessel with internally or externally threaded fittings mechanically attached using arc-welded or resistance-welded stud shall be established by proof test in accordance with HG-500. Each size of the proposed connection shall be tested including the gasket method, studs, and internally or externally threaded fittings.

(l) Welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(m) All other requirements of Section IV shall be met.

(n) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2968

Mandatory Appendix 5, Alternative Pressure Relief Device

Section IV

Approval Date: August 28, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it acceptable to utilize an ASME-certified rupture disc device as an alternative for the safety relief valve required under Section IV, Mandatory Appendix 5, 5-600(c)?

Reply: It is the opinion of the Committee that an ASME-certified rupture disc device, bearing the UD designator may be used as the sole pressure relieving device on a vacuum (only) boiler, provided the following requirements are met:

(a) The rupture disc device shall comply fully with the requirements of Section VIII, Division 1, UG-127(a), UG-129(e), UG-130, UG-131, UG-134(a), UG-134(e), UG-135, and UG-137.

(b) All other requirements of Section IV shall apply.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2969-2

F-Number Grouping for Co-26Cr-9Ni-5Mo-3Fe-2W Alloy (UNS R31233) Filler Metal

Section I; Section VIII, Division 1; Section IX

Approval Date: September 3, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternate rules may be applied to grouping UNS R31233 Co-Cr-Ni-Mo-W welding filler metal meeting the chemical requirements of [Table 1](#) but otherwise conforming to SFA-5.21 to reduce the number of welding procedures and performance qualifications?

Reply: It is the opinion of the Committee that UNS R31233 Co-26Cr-9Ni-5Mo-3Fe-2W welding filler metal meeting the chemical requirements of [Table 1](#) but otherwise conforming to SFA-5.21 may be considered as F-No. 72 for both procedure and performance qualification purposes. Further, this material shall be identified as UNS R31233 in the welding procedure specification, procedure qualification, and performance qualification records.

This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements (UNS R31233)

Element	Weight, %
Co	Remainder
Cr	23.5-27.5
Ni	7.0-11.0
Mo	4.0-6.0
Fe	1.0-5.0
W	1.0-3.0
Mo	0.1-1.5
Si	0.05-1.0
N	0.03-0.12
C	0.02-0.10
P	0.03 max.
S	0.02 max.
B	0.015 max.

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Case 2970

Equivalent Pressure Cycling for Composite Pressure Vessels for High Pressure Fluids

Section X

Approval Date: October 15, 2018

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions and requirements may equivalent pressure cycle testing be conducted on a pressure vessel and used to demonstrate compliance with the User's Design Specification cycle requirements under the rules of Section X, Mandatory Appendix 8 for Class III vessels with non-load-sharing liners?

Reply: It is the opinion of the Committee that a Class III composite pressure vessel tested at a specified pressure range and number of cycles may be used to assess compliance with a User's Design Specification that requires a given number of cycles at the same or lower pressure ranges, including a combination of full and partial cycles, using the approach detailed as follows.

The following provides guidance for the development of S-N diagrams and Goodman diagrams with the purpose of evaluating full pressure cycles conducted at a given pressure range, and providing assurance that the pressure vessel can meet the User's Design Specification life requirements with high reliability at equal or lower pressures and pressure ranges.

1 DEVELOPING AN S-N DIAGRAM

The pressure vessel manufacturer is responsible for developing the S-N diagram based on using the same materials and manufacturing approach used for the pressure vessels to be developed. The pressure vessel manufacturer must have built the vessels tested for use in developing the S-N diagram and Goodman Diagram.

(a) The following steps are required:

Step 1. Establish the mean burst pressure of the vessel used to develop the S-N diagram. A minimum of 10 units are required. Plot this point as 100% stress, 1 cycle on the S-N diagram.

Step 2. Cycle a minimum of four pressure vessels from no more than 10% of nominal working pressure to a first specified pressure level for which the stress is known. Plot this point on the S-N diagram. The S

value will be stress relative to the mean burst, the N value will be either the point of first failure, or the point at which cycling was stopped if there was no failure.

Step 3. Cycle a minimum of four pressure vessels from no more than 10% of nominal working pressure to a second specified pressure level for which the stress is known. Plot this point on the S-N diagram as was done for the first specified pressure level.

Step 4. Draw a line from the 100%-1 point (burst) through the fatigue point that gives the lower of lines. This will be the characteristic line.

(b) The following criteria also apply:

(1) More than two fatigue points may be plotted.

(2) For the data point plotted, either:

(-a) One point must have more than 10,000 cycles, and one point must have more than 100,000 cycles, or

(-b) Partial cycles may only be projected to a limit of 20 times the point with higher cycles.

(3) Fatigue point data may be used from different pressure vessel designs, given that plotting is done as a percent of strength, providing the construction is sufficiently similar so as to give consistent fatigue results. Any vessel used for fatigue testing must use a percent of strength based on burst testing of that specific design.

(4) To provide consistency of results, the test vessels must meet the following criteria:

(-a) Test vessels must be at least 9 in. in diameter.

(-b) The cylinder length (total vessel length less domes and end features) must have a cylinder length at least equal to the diameter.

(-c) The primary reinforcing materials must be the same.

(-1) Carbon reinforced vessel testing results may be used for carbon and carbon/glass vessel evaluation.

(-2) Carbon/glass reinforced vessel testing results may be used for carbon and carbon/glass vessel evaluation.

(-3) All-glass reinforced vessel testing results may be used for all-glass vessel evaluation.

Figure 1 illustrates an S-N diagram based on the above development, using actual data.

2 EQUIVALENT PRESSURE CYCLING

The S-N diagram (Figure 1) can be used to specify an alternate pressure to demonstrate fatigue resistance. The following are examples:

(a) Assume the requirement for full cycles is 10^7 full pressure cycles (10,000,000). The vessel must be designed so the stress is no more than 40% of the mean burst pressure.

(b) The same vessel can be expected to withstand about 10^2 full pressure cycles (100) at about 80% of the mean burst pressure. If pressure cycles exceed 100% to 80% pressure without failure, the design is qualified.

(c) If some vessels fail before the required number of cycles, then the failure line would have to be lowered accordingly, and the vessel would need to operate at a correspondingly lower stress level to be certified.

3 DEVELOPING A GOODMAN DIAGRAM

A Goodman diagram, shown in Figure 2, may be developed as given in Table 1, from the S-N diagram, shown in Figure 1, as follows:

Step 1. Identify the fatigue levels from the S-N diagram to be used in the Goodman diagram (Table 1, first column).

Step 2. Identify the stress level (i.e., at upper cycle pressure) from the S-N diagram that corresponds with that fatigue level (Table 1, second column).

NOTE: Stress levels are given as a fraction of the ultimate strength.

Step 3. Identify the lower stress level (i.e., at lower cycle pressure) associated with the fatigue level (Table 1, third column).

NOTE: Some fatigue testing is done with a lower limit that is as high as 10% of the maximum working pressure, but might be near zero. For purposes of this example, the lower cycle pressure is set at zero.

Step 4. Calculate the average stress level for the pressure cycle (Table 1, fourth column).

NOTE: This is equal to one-half of the upper limit plus the lower limit.

Step 5. Calculate the amplitude for pressure cycle (Table 1, fifth column).

NOTE: This is equal to the average stress level minus the lower stress level (equal to one-half of the upper limit minus the lower limit).

Step 6. Enter the coordinates for the second point of each line (Table 1, sixth and seventh columns). Since this represents the tensile strength, such as in a burst test, these coordinates will be the same for all fatigue lines, and will have a normalized value of 1.0 for the upper limit, and a value of 0.0 for the amplitude.

Step 7. From the two sets of (X, Y) coordinates, calculate the slope of the resultant line (Table 1, eighth column), and the intercept of the Y-axis (Table 1, ninth column).

The manufacturer may specify the pressure ranges, and cycles in each pressure range, expected to be seen over the life of the pressure vessel, and show that there is margin on the fatigue life. The analysis may use, if appropriate, a means to equate the pressure ranges to a common reference datum, e.g., a Goodman type Constant Life Diagram, and shall assess the fraction of life used in each pressure range and subsequent summation of expected life, e.g., using Miner's Rule. The result must have a factor of safety of 1.0 or higher. This analysis must be done for the composite and metallic components of a pressure vessel.

Table 2 gives an example of a sample pressure cycle specification. In this example, the burst pressure is 2.25 times the maximum upper pressure ($100 \times 2.25 = 225$). This data can be put into the nondimensional terms to plot on the Goodman Diagram, as given in Table 3, using the approach described above.

The points can be plotted on the Goodman diagram, Figure 2. Lines can be plotted similarly to the previous lines. It is also possible to get an equivalent cycle range where the lower pressure limit is 0, by intersecting the "reliability" line with one from the point 0,0 with a slope of 1. It can be seen that data set number 1 lies between the 1×10^6 and 1×10^7 lines, while the other two points lie below the 1×10^8 line. From this information, it is possible to estimate the total fraction of life used, as shown in Table 4. The resultant factor of safety can be calculated as $FS > 1/0.109 = 9.2$.

Table 1
Goodman Diagram Development

Fatigue Level	Upper Cycle Limit	Lower Cycle Limit	Average Stress, X2	Amplitude, Y2	Strength, X1	Amplitude, Y1	Slope, <i>m</i>	Intercept, <i>b</i>
1×10^1	0.92	0.0	0.460	0.460	1.0	0.0	-0.8518	0.85
1×10^2	0.83	0.0	0.415	0.415	1.0	0.0	-0.7094	0.71
1×10^3	0.74	0.0	0.370	0.370	1.0	0.0	-0.5873	0.59
1×10^4	0.66	0.0	0.330	0.330	1.0	0.0	-0.4925	0.49
1×10^5	0.60	0.0	0.300	0.300	1.0	0.0	-0.4286	0.43
1×10^6	0.50	0.0	0.250	0.250	1.0	0.0	-0.3333	0.33
1×10^7	0.40	0.0	0.200	0.200	1.0	0.0	-0.2500	0.25
1×10^8	0.31	0.0	0.155	0.155	1.0	0.0	-0.1834	0.18

GENERAL NOTE: The last four lines of this table are shown in [Figure 2](#). More lines could be plotted if needed.

Table 2
Sample Pressure Cycle Specification

Set No.	Lower Pressure	Upper Pressure	<i>R</i>	Number of Cycles
1	0	100	0	100,000
2	30	70	0.429	400,000
3	70	100	0.7	500,000

Table 3
Normalized Sample Terms

Set Number	Lower Limit Ratio	Upper Limit Ratio
1	0.222	0.222
2	0.222	0.0889
773	0.3778	0.0667

Table 4
Life Evaluation

Set Number	Number of Cycles	Life Fraction	LF Value
1	100,000	<100,000/1 E+06	<0.100
2	400,000	<400,000/1 E+08	<0.004
3	500,000	<500,000/1 E+08	<0.005
Sum (Miner's Rule)			<0.109

Figure 1
Carbon Composite Fatigue Life vs. Load Level

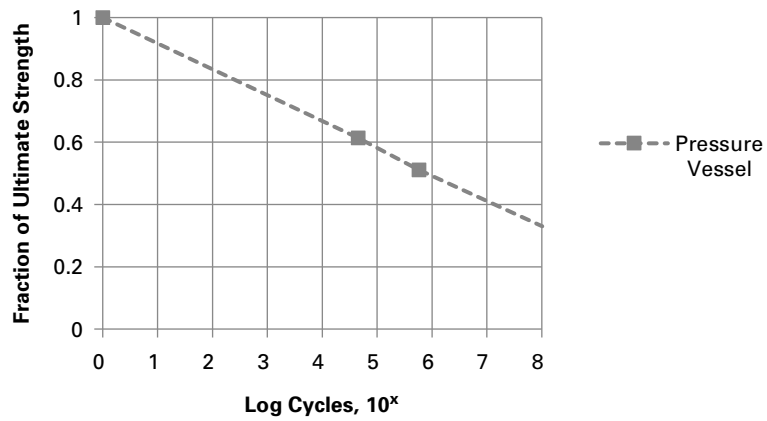
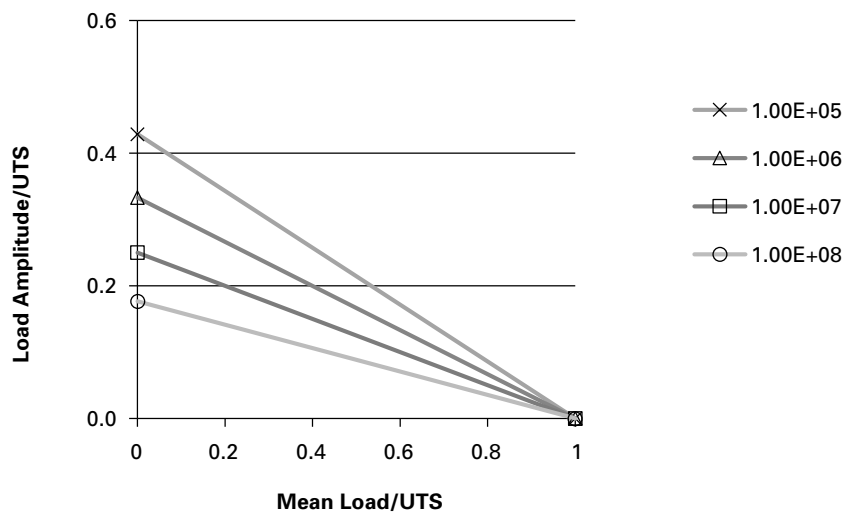


Figure 2
Goodman Type Constant Life Diagram



Case 2971-1

Qualification of Welding Procedures for High Frequency Induction Longitudinal Butt Welds in Tube Construction

Section VIII, Division 1; Section IX

Approval Date: September 3, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may welding procedures for longitudinal high frequency induction butt welds be qualified for tube construction in accordance with Section IX?

Reply: It is the opinion of the Committee that welding procedures for longitudinal high frequency induction butt welds be qualified for tube construction in accordance with Section IX, provided the following requirements are met:

(a) *Welding Procedure Specification (WPS) Qualification*

(1) The welding procedure shall be qualified by preparing a longitudinal high frequency induction butt weld in a tubular test coupon, observing and recording the values for the essential variables listed in [Table 1](#).

(2) The base material shall be P-No. 1 having a thickness range of 0.054 in. (1.4 mm) minimum to 0.075 in. (1.9 mm) maximum.

(3) The completed test coupon shall be subjected to the mechanical tests required by QW-451.1.

(4) The welds shall be tested as a butt joint weld in accordance with QW-150 and QW-160.

(5) The test specimens removed from the welded test coupon may be flattened prior to testing.

(6) A change from a butt welded joint to any other type of weld joint is not permitted.

(b) Welding operator performance qualification for high frequency induction butt welding shall be in accordance with QW-305 and QW-361.

(c) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
High Frequency Induction Welding Variables

Paragraph	Subparagraph	Brief of Variables
QW-402	.1	Ø Groove type
QW-403	.1	Ø P-No.
	.21	± Coating, plating
	.22	± T
QW-407	.1	Ø PWHT
QW-409	.15	Ø Pressure, current, and time
	.17	Ø Power supply
	.18	Ø Tip cleaning
QW-410	.31	Ø Cleaning method
	.32	Ø Pressure, time
	.33	Ø Equipment
	.34	Ø Cooling medium

Legend

+ = Addition

- = Deletion

Ø = Change

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Case 2972

Marking for Small Parts 5 in. (125 mm) O.D. and Under

Section IV

Approval Date: October 6, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may small parts for which a Manufacturer's Partial Data Report is required, in lieu of the marking requirements of HG-531, be marked with an alternative form of identification and without the Certification Mark?

Reply: It is the opinion of the Committee that small parts for which a Manufacturer's Partial Data Report is required, in lieu of the marking requirements of HG-531, may be marked with an alternative form of identification and

without the Certification Mark, provided the following requirements are met:

(a) This Case shall be applicable to small parts 5 in. (125 mm) O.D. and under.

(b) The part shall be marked with an identification acceptable to the Authorized Inspector (e.g., bar coding, etching, stencil) and traceable to the Form H-4 Manufacturer's Partial Data Report.

(c) The marking shall be of a type that will remain visible until the part is installed.

(d) All other requirements of Section IV shall apply.

(e) This Case number shall be shown on the Form H-4 Manufacturer's Partial Data Report under "Remarks" section.

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Case 2973

Use of Nickel Alloy UNS N08367 in the Manufacture of Part HLW Water Heaters and Storage Tanks

Section IV

Approval Date: November 21, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may nickel alloy UNS N08367 meeting the requirements of the applicable Section II, Part B specifications be used in the construction of unlined Section IV, Part HLW water heaters and storage tanks?

Reply: It is the opinion of the Committee that nickel alloy UNS N08367 meeting the requirements of the applicable Section II, Part B specifications may be used in the construction of unlined Section IV, Part HLW water heaters and storage tanks, provided the following requirements are met:

(a) Material shall conform to one of the specifications listed in [Table 1](#).

(b) The maximum allowable stress values shall be as listed in [Tables 2, 2M, 3, and 3M](#).

(c) Welding procedure and performance qualification shall be conducted in accordance with Section IX. This material shall be considered P-No. 45.

(d) For external pressure, Section II, Part D, Figure NFN-12 shall be used.

(e) The maximum design temperature shall be 500°F (260°C).

(f) All other applicable requirements of Section IV, Part HLW shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

NOTE: For products in welded form, the allowable stress values have been multiplied by a factor of 0.85.

Table 1
Product Forms and Specifications

Product Form	Specification
Bar, rod, and wire	SB-691
Forgings	SB-462, SB-564
Plate, sheet, and strip	SB-688
Seamless and welded fittings	SB-366
Seamless pipe and tube	SB-690
Welded pipe	SB-675
Welded tube	SB-676

Table 2

Maximum Allowable Stress Values for Material With 45 ksi Yield Strength and 95 ksi Tensile Strength

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Seamless	Welded
100	23.8	20.2
200	23.8	20.2
300	22.5	19.1
400	21.5	18.3
500	20.5	17.4

Table 3

Maximum Allowable Stress Values for Material With 45 ksi Yield Strength and 100 ksi Tensile Strength

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Seamless	Welded
100	25.0	21.3
200	25.0	21.3
300	23.6	20.1
400	21.9	18.6
500	20.5	17.4

Table 2M

Maximum Allowable Stress Values for Material With 310 MPa Yield Strength and 655 MPa Tensile Strength

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Seamless	Welded
40	164	139
100	164	139
150	155	132
200	149	127
250	143	122
275 [Note (1)]	139	118

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

Table 3M

Maximum Allowable Stress Values for Material With 310 MPa Yield Strength and 690 MPa Tensile Strength

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Seamless	Welded
40	172	146
100	172	146
150	163	139
200	152	129
250	143	122
275 [Note (1)]	139	118

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

Case 2974

Use of Lap Joint Flanges for Nozzles, Manways, and Body Flanges for Installation on Class II Equipment

Section X

Approval Date: November 1, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May lap joint flanges be permitted for flanged nozzles, manways, and body flanges on equipment constructed and marked in accordance with Section X, Class II?

Reply: It is the opinion of the Committee that lap joint flanges may be permitted on nozzles, manways, and body flanges on equipment constructed and marked in accordance with Section X, Class II, provided the following requirements are met:

(a) The design of a FRP backing ring and stub end shall be in accordance with Article RD-11. Metallic backing rings shall be designed in accordance with Section VIII, Division 1.

(b) Nozzles shall have a maximum inside diameter of 24 in. (610 mm) when the flange drilling is in accordance with ASME B16.5 Class 150. Larger sizes may use custom drilling patterns or ASME B16.4 Series A Class 150 drilling patterns. Custom drilling patterns are allowed on all sizes.

(c) Minimum pressure rating of the stub end and backing ring flange shall be in accordance with (1), (2), and (3). Maximum pressure rating for any size or type lap joint nozzle or flange shall be 150 psig (1.03 MPa).

(1) Nozzles up to 24 in. (610 mm) inside diameter shall have a minimum pressure rating of 50 psig (345 kPa) or the design pressure of the vessel plus static head as applicable, whichever is greater.

(2) Side manways, nozzle flanges larger than 24 in. (610 mm), and body flanges shall have a minimum pressure rating of 15 psig (103 kPa) or the design pressure of the vessel plus static head as applicable, whichever is greater.

(3) Top manways shall be designed for the worst condition of gasket seating loading or the design pressure of the vessel, whichever is greater.

(d) The backing ring shall be either of metallic or FRP construction. FRP backing rings shall be designed per (a).

(e) Metallic materials shall be listed in Section VIII, Division 1, Part UCS, UHA, UNF, or UDI.

(f) Allowable stress for metallic backing rings shall not exceed those listed in Section II, Part D with allowables as per Section VIII, Division 1.

(g) FRP backing rings shall be constructed of laminates with material properties established per Articles RM-1 and RT-7 and shall be designed per (a).

(h) FRP backing rings shall not be split into two or more ring segments. Metal backing rings may be split in accordance with Section VIII, Division 1, Mandatory Appendix 2, para. 2-9.

NOTE: Making split backing rings twice as thick as an unsplit ring normally satisfies the criteria of Section VIII, Division 1, Mandatory Appendix 2, para. 2-9.

(i) Flange stops or retainers shall be provided for all nozzles 8 in. (203 mm) and larger with metallic backing rings and all nozzles 16 in. (406 mm) and larger with FRP backing rings whose axis is vertical or within 45 deg of vertical where the backing ring flange is facing upward. Nozzle necks may need to be longer than 6 in. (150 mm) to allow for attachment laminates, gussets, hub layups, and nozzle end lap and backing ring thicknesses.

(j) Stub ends on nozzles 4 in. (102 mm) I.D. and under shall have gussets extending to within 1 in. (25 mm) of the back side of the backing ring.

(k) The end lap on the stub end shall be molded integrally with the nozzle neck with a minimum inside radius of $\frac{1}{8}$ in. (3 mm) where it joins the hub. See Figure 1.

(l) The backing ring I.D. shall be chamfered or radiused sufficiently to clear the radius where the nozzle end lap (the ring attached integrally to the end of the stub end or nozzle neck) meets the outside of the hub. See Figure 1.

(m) The rigidity factor of a metallic backing ring shall be less than or equal to 1.0 when calculated per Section VIII, Division 1, Mandatory Appendix 2, para. 2-14. The axial rotation of the backing ring shall be limited to 1.5 deg under the worst loading conditions. This criteria may be shown to be met using design Method B in Article RD-11. In addition to the rotation deflection limit, the flange shall also meet the applicable stress criteria given in Method B. See Figure 1.

(n) The backing ring shall have a maximum nominal radial clearance with the O.D. of the hub of $\frac{1}{16}$ in. (1.5 mm) on nozzles and manways 24 in. (610 mm)

and smaller with a maximum radial clearance of $\frac{1}{8}$ in. (3 mm) on larger size nozzles, manways, and body flanges. Machining may be used to achieve these tolerances, but the machining shall not breach any woven roving layers and shall be resin-coated afterwards.

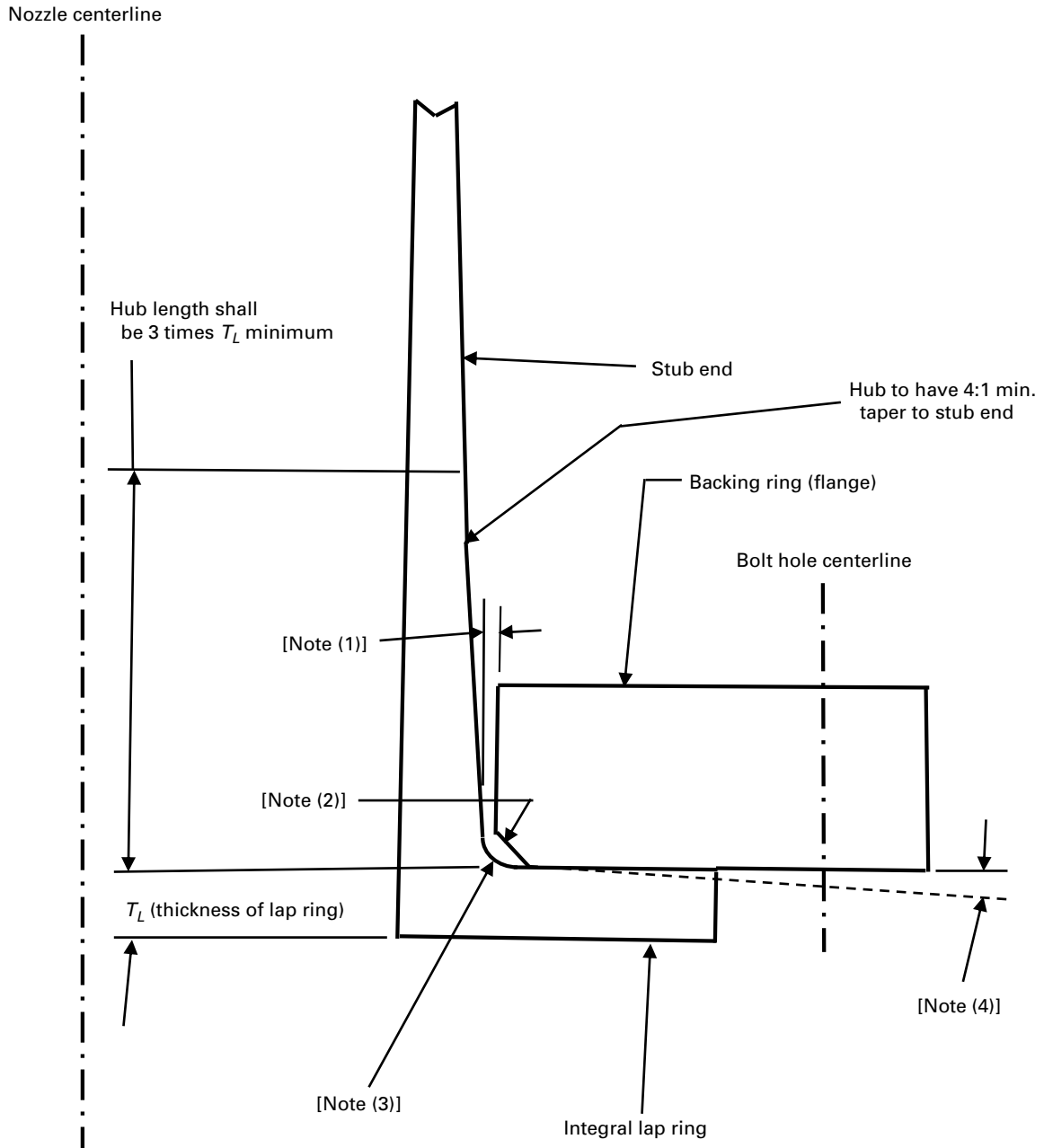
(o) The bearing stress between the backing ring and the back surface of the end lap shall not exceed 5,000 psi (34.5 MPa).

(p) The design of the reinforcing pad for lap joint stub ends shall take into consideration the extra loading due to weight of the backing ring plus all other applicable loadings.

(q) The O.D. of the lap ring shall be within $\frac{1}{16}$ in. (1.5 mm) radially of the backing ring bolt hole opening on nozzles up to 26 in. (406 mm) and within $\frac{1}{8}$ in. (3 mm) radially on larger size nozzles.

(r) This Case number shall be shown on the Fabricator's Data Report Form RP-3.

Figure 1
Lap Joint Flange



NOTES:

- (1) Hub clearance with backing ring; see (q).
- (2) Backing ring chamfer; see (l).
- (3) Minimum radius of $\frac{1}{8}$ in. (3 mm); see (k).
- (4) Maximum rotation of backing ring is limited; see (m).

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Case 2975

Vessel Weight Requirements for Class I Vessels

Section X

Approval Date: November 1, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to accept a vessel weight less than 95% of the weight specified and recorded in the original Qualification Test Report and Procedure Specification for a Section X, Class I pressure vessel as required by RT-430, provided all requirements of Section X have been satisfied?

Reply: It is the opinion of the Committee that Fabricators of Class I pressure vessels may accept a vessel weight less than 95% of the weight specified and recorded in the original Qualification Test Report and Procedure Specifi-

cation as required by RT-430, provided the following requirements are met:

(a) The vessel weight shall be at least 90% of the weight specified and recorded in the original Fabricator's Qualification Test Report and Procedure Specification.

(b) A volumetric expansion test shall be performed in accordance with the requirements of RT-222, and the results of this test shall not be greater than 105% of the values recorded in the original Qualification Test Report and Procedure Specification.

(c) No other material or process changes of the essential variables shall be permitted from the original qualification vessel when manufacturing the duplicate vessels.

(d) This Case shall only apply to the fabrication method of filament-winding process, Class I pressure vessels.

(e) This Case number shall be recorded on the appropriate Section X Fabricator's Data Reports.

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Case 2976

Use of Alloy SUS304TP Pipe in Accordance With JIS G 3459:2016 in the Construction of Heating Boilers Per Part HF

Section IV

Approval Date: October 11, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may Alloy SUS304TP pipe meeting the material requirements of JIS G 3459:2016 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that Alloy SUS304TP pipe meeting the material requirements of JIS G 3459:2016 may be used in the construction of heating boilers under Section IV, Part HF providing the following requirements are met:

- (a) The allowable stress values for seamless tube with Alloy SUS304TP shall be as listed in [Table 1](#) and [Table 1M](#).
- (b) The minimum tensile strength shall be 75 ksi (520 MPa).
- (c) The minimum yield strength shall be 30 ksi (205 MPa).
- (d) For the purpose of welding and brazing procedures and performance qualifications, this material shall be considered P-No. 8, Group 1.
- (e) For external pressure, Section II, Part D, Figure HA-1 shall be used.
- (f) Flattening or flaring tests shall be made on all pipe including seamless pipe as defined in JIS G 3459:2016, para. 6.2.1.
- (g) The nominal elongation value of 35% listed in JIS G 3459, Table 4 is based on pipe with a wall thickness of 0.315 in. (8 mm) or greater when tested with a No. 11 or

No. 12 test piece. The minimum elongation values in [Table 2](#) are based on pipe with a wall thickness less than 0.315 in. (8 mm) when tested using a No. 12 or No. 5 test piece. [Table 2](#) shall apply to all pipe whose outside diameter is 1.574 in. (40 mm) or greater and the wall thickness is less than 0.315 in. (8 mm). Pipe whose outside diameter is less than 1.574 in. (40 mm) shall be elongation tested using test piece No. 11. The test results shall be documented and filed for reference.

(h) The pipe shall be made by a seamless process, laser welding, electric resistance welding, or by an automatic welding process with no addition of filler metal in the welding operation.

(i) Pipes shall be subjected to a heat treatment by the manufacturer as specified in JIS G 3459:2016 para. 4(b) and Table 2, Heat Treatment. Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of JIS G 3459:2016, Table 2 shall apply.

(j) The materials Manufacturer or vendor shall submit inspection documents (Reference JIS G 3459:2016, clauses 15 and 17) to the purchaser with a statement that the pipe has been manufactured, inspected, and tested in accordance with the requirements of the JIS Specification and this Case.

(k) The materials Manufacturer or vendor shall identify the material being provided. The identification shall be traceable to the inspection documents.

(l) All other requirements of Section IV shall be met.

(m) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
Up to 100	15.0
150	15.0
200	14.2
250	13.6
300	13.2
350	13.0
400	12.8
450	12.7
500	12.7

GENERAL NOTE: For welded pipe, the stress values listed in this Table shall be multiplied by a weld joint factor of 0.85.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	103
65	103
100	96.9
125	93.6
150	91.2
175	89.5
200	88.4
225	87.7
250	87.5
275 [Note (1)]	87.4

GENERAL NOTE: For welded pipe, the stress values listed in this Table shall be multiplied by a weld joint factor of 0.85.

NOTE: (1) The maximum allowable use temperature is 260°C. The value for 275°C is provided for interpolation only.

Table 2
Minimum Elongation, %, for Alloy SUS304TP Pipe With Wall Thickness Under 0.315 in. (8 mm) Tested Using Test Pieces No. 12 Strip Form (Pipe Axis Direction) or No. 5 (Perpendicular to Axis)

Test Piece Per JIS Z 2241:2011 Austenitic Pipes	Wall Thickness, in. (mm)							
	0.039 in. (1 mm) or Under	>0.039 in. (>1 mm) Up to 0.079 in. (2 mm)	>0.079 in. (>2 mm) Up to 0.118 in. (3 mm)	>0.118 in. (>3 mm) Up to 0.157 in. (4 mm)	>0.157 in. (>4 mm) Up to 0.197 in. (5 mm)	>0.197 in. (>5 mm) Up to 0.236 in. (6 mm)	>0.236 in. (>6 mm) Up to 0.276 in. (7 mm)	>0.276 in. (>7 mm) But Less Than 0.315 in. (8 mm)
No. 12 Strip Form Parallel to axis	24%	26%	28%	29%	30%	32%	34%	35%
No. 5 Perpendicular to pipe axis	14%	16%	18%	19%	20%	22%	24%	25%

Case 2978

Use of Aluminum Alloy EN AW-6060 T66 Extruded Tube in the Manufacture of Hot Water Heating Boilers

Section IV

Approval Date: July 16, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May aluminum alloy EN AW-6060 T66 extruded tube be used in construction for hot water heating boilers under the rules of Section IV, Part HF?

Reply: It is the opinion of the Committee that aluminum alloy EN AW-6060 T66 extruded tube may be used in Section IV, Part HF construction of hot water heating boilers, provided the following requirements are met:

(a) The chemical composition shall be according to EN 573-3:2013 (see [Table 1](#)).

(b) The mechanical properties shall be according to EN 755-2:2016 (see [Table 1](#)). The specified minimum tensile strength at room temperature shall be 31.0 ksi (215 MPa) and the specified minimum yield strength at room temperature shall be 23.0 ksi (160 MPa).

(c) The technical conditions for inspection and delivery shall be according to EN 755-1:2016 (see [Table 1](#)) except for the following:

(1) Inspection document type 2.2, 3.1, or 3.2 shall be furnished.

(2) Tubes shall be marked. The marking shall include, as a minimum, the manufacturer's name or trademark, the specification designation (EN 755-2), the alloy designation and temper of the tube (EN AW-6060 T66). For tubes with outside diameter $D \leq 2$ in. (51 mm) the marking on tubes, may be replaced by the marking on a label attached to the bundle or box.

(d) The temper designation shall be according to EN 515:2017 (see [Table 1](#)).

(e) The maximum allowable working pressure shall not exceed 50 psi (345 kPa).

(f) The maximum water temperature shall be 210°F (99°C).

(g) The maximum allowable stress values shall be as shown in [Table 2](#) and [Table 2M](#).

(h) For external pressure, Section II, Part D, Figure NFA-12 shall be used.

(i) The minimum thickness shall be $\frac{1}{8}$ in. (3 mm), according to HF-301.2.

(j) The material shall not be brazed nor welded.

(k) All other applicable parts of Section IV shall apply.

(l) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

Table 1
Applicable Specifications

Specification	Title
EN 515:2017	Aluminium and aluminium alloys — Wrought products — Temper designations
EN 573-3:2013	Aluminium and aluminium alloys — Chemical composition and form of wrought products — Part 3: Chemical composition and form of products
EN 755-1:2016	Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 1: Technical conditions for inspection and delivery
EN 755-2:2016	Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 2: Mechanical properties

GENERAL NOTE: See Section II, Part B, Nonmandatory Appendix A, for ordering information to obtain English language copies of these EN standards and their references.

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	6.2
150	6.2
200	6.2
250	6.0
300 [Note (1)]	5.9

NOTE: (1) The maximum metal use temperature is 266°F. Value for 300°F is provided for interpolation purposes.

Table 2M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	43.0
65	43.0
100	43.0
125	41.3
150 [Note (1)]	40.8

NOTE: (1) The maximum metal use temperature is 130°C. Value for 150°C is provided for interpolation purposes.

Case 2979

Use of Existing Nameplates in Inventory for Construction

Section VIII, Division 1

Approval Date: December 4, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For construction to the 2019 Edition, may existing stock of nameplates be used for markings in accordance with Section VIII, Division 1, Figure UG-118 of the 2017 Edition, which include the following type

of construction markings: “W” for arc or gas welding, “P” for pressure welded (except resistance), “B” for brazed, and “RES” for resistance welded?

Reply: It is the opinion of the Committee that existing stock of nameplates that have a marking arrangement as shown in Figure UG-118 of the 2017 Edition may be used for construction to the 2019 Edition. This Case number shall be shown on the Manufacturer's Data Report.

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Case 2981

KE-112.1 References to Section V, T-120

Section VIII, Division 3

Approval Date: November 1, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Instead of T-120(e), (f), (h), or (i) of Section V, may T-120 (e), (f), (g), (i), (j), or (k) be used as one of the references in KE-112.1?

Reply: It is the opinion of the Committee that Section V, T-120(e), (f), (g), (i), (j), or (k) may be used instead of T-120(e), (f), (h), or (i) as one of the references in KE-112.1, provided the following requirement is met:

(a) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2982-2*

35Ni–30Fe–27Cr–6.5Mo–N Nickel Alloy, UNS N08935

(25)

Section VIII, Division 1; Section VIII, Division 2

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed 35Ni–30Fe–27Cr–6.5Mo–N (UNS N08935) seamless pipe and tube; sheet, strip, and plate; and bar with the chemical composition conforming to [Table 1](#), mechanical properties conforming to [Tables 2](#) and [2M](#) and otherwise conforming to the respective requirements of the applicable product specification in [Table 3](#) be used for welded construction under the rules of Section VIII, Division 1 or 2?

Reply: It is the opinion of the Committee that solution annealed 35Ni–30Fe–27Cr–6.5Mo–N (UNS N08935) seamless pipe and tube; sheet, strip, and plate; and bar as described in the Inquiry may be used in welded construction under the rules of Section VIII, Division 1 or 2, provided the following requirements are met:

(a) The maximum design temperature shall be 842°F (450°C).

(b) The material shall be furnished in the annealed condition.

(c) For external pressure design, Figure NFN-12 and Table NFN-12 in Section II, Part D shall apply.

(d) For Section VIII, Division 1, the maximum allowable stress values for the material shall be those given in [Table 4](#) and [Table 4M](#).

(e) For Section VIII, Division 2, Class 1, the maximum allowable stress values for the material shall be those given in [Table 5](#) and [Table 5M](#).

(f) For Section VIII, Division 2, Class 2, the maximum allowable stress values for the material shall be those given in [Table 6](#) and [Table 6M](#).

(g) Separate welding procedure and performance qualifications shall be conducted in accordance with Section IX. Procedure and performance qualifications qualified under previous versions of this Case do not require requalification.

(h) The yield strength and tensile strength values are shown in [Tables 7](#) and [7M](#).

(i) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of [\(b\)](#) shall apply.

(j) The physical properties as follows shall apply:

(1) Density is 0.291 lb/in.³ (8.05 g/cm³).

(2) Thermal expansion is shown in [Tables 8](#) and [8M](#).

(3) Thermal conductivity and thermal diffusivity are shown in [Tables 9](#) and [9M](#).

(4) The modulus of elasticity and Poisson's ratio are shown in [Tables 10](#) and [10M](#).

(k) For Division 2 fatigue analysis, this material shall be considered Figure 3-F.3/Figure 3-F.3M material.

(l) The rules in Section VIII, Division 1, Subsection C that shall apply are those in Part UNF for nickel alloys. For Section VIII, Division 2 applications, the rules for nickel alloys shall apply.

(m) This Case number shall be shown in the marking and on the certification of the material and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Compositional Limit, %
Carbon	0.030 max.
Manganese	1.2 max.
Phosphorous	0.030 max.
Sulfur	0.020 max.
Silicon	0.5 max.
Chromium	26.0–28.0
Nickel	34.0–36.0
Molybdenum	6.1–7.1
Iron	Remainder [Note (1)]
Copper	0.4 max.
Nitrogen	0.25–0.36

NOTE: (1) Element shall be determined arithmetically by difference.

* Corrected by errata, ASME BPVC.CC-2025, July 2025.

Table 2
Mechanical Test Requirements (Room Temperature)

Sheet, Strip, and Plate <0.25 in; Seamless Tube	
Tensile strength, min., ksi	109
Yield strength, 0.2% offset, min., ksi	62
Seamless Pipe	
Tensile strength, min., ksi	109
Yield strength, 0.2% offset, min., ksi	58
Seamless Pipe and Tube	
Elongation, in 2 in., min., %	35
Sheet, Strip, and Plate <0.25 in.	
Elongation, in 2 in., min., %	40
Plate ≥0.25 in. and Bar	
Tensile strength, min., ksi	102
Yield strength, 0.2% offset, min., ksi	51
Elongation, in 2 in., min., %	40

Table 2M
Mechanical Test Requirements (Room Temperature)

Sheet, Strip, and Plate <6.35 mm; Seamless Tube	
Tensile strength, min., MPa	750
Yield strength, 0.2% offset, min., MPa	425
Seamless Pipe	
Tensile strength, min., MPa	750
Yield strength, 0.2% offset, min., MPa	400
Seamless Pipe and Tube	
Elongation, in 50 mm, min., %	35
Sheet, Strip, and Plate <6.35 mm	
Elongation, in 50 mm, min., %	40
Plate ≥6.35 mm and Bar	
Tensile strength, min., MPa	700
Yield strength, 0.2% offset, min., MPa	350
Elongation, in 50 mm, min., %	40

Table 3
Product Specifications

Product	Specification
Bar	SB-649
Seamless tube	SB-163
Seamless pipe	SB-677
Sheet, strip, and plate	SB-625

Table 4
Maximum Allowable Stress Values — Section VIII, Division 1

For Metal Temperature Not Exceeding, °F	Seamless Tube; Sheet, Strip, and Plate <0.25 in.		Seamless Pipe		Plate ≥0.25 in. and Bar	
	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]
75	31.1	31.1	31.1	31.1	29.1	29.1
100	31.1	31.1	31.1	31.1	29.1	29.1
200	31.0	31.0	31.1	31.1	28.0	29.1
300	29.4	29.4	29.1	29.5	25.6	27.6
400	28.4	28.4	27.3	28.5	24.0	26.6
500	27.5	27.7	25.9	27.7	22.8	26.0
600	26.3	27.2	24.7	27.2	21.8	25.5
700	25.3	26.7	23.8	26.7	20.9	25.0
800	24.6	26.2	23.1	26.2	20.3	24.5
900	24.2 [Note (2)]	25.5 [Note (2)]	22.8 [Note (2)]	25.5 [Note (2)]	20.0 [Note (2)]	23.9 [Note (1)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only. The maximum use temperature is 842°F.

Table 4M
Maximum Allowable Stress Values — Section VIII, Division 1

For Metal Temperature Not Exceeding, °C	Seamless Tube; Sheet, Strip, and Plate <6.35 mm		Seamless Pipe		Bar and Plate ≥6.35 mm	
	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]
40	214	214	215	215	201	201
65	214	214	215	215	201	201
100	212	212	213	213	191	199
150	203	203	200	203	176	190
200	196	196	189	197	166	184
250	192	192	180	192	158	180
300	184	188	173	189	152	176
350	177	185	166	186	146	174
400	171	182	161	183	142	171
450	168	179	158	179	139	167

NOTE: (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 5
Maximum Allowable Stress Values — Section VIII, Division 2, Class 1

For Metal Temperature Not Exceeding, °F	Seamless Tube; Sheet, Strip, and Plate <0.25 in.		Seamless Pipe		Plate ≥0.25 in. and Bar	
	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]
75	36.3	36.3	36.3	36.3	34.0	34.0
100	36.3	36.3	36.3	36.3	34.0	34.0
200	33.8	36.2	31.8	36.3	28.0	33.9
300	30.9	34.4	29.1	34.4	25.6	32.2
400	29.0	33.1	27.3	33.2	24.0	31.1
500	27.5	32.3	25.9	32.4	22.8	30.3
600	26.3	31.7	24.7	31.8	21.8	29.4
700	25.3	31.1	23.8	31.2	20.9	28.2
800	24.6	30.5	23.1	30.6	20.3	27.4
900	24.2 [Note (2)]	29.7 [Note (2)]	22.8 [Note (2)]	29.8 [Note (2)]	20.0 [Note (2)]	27.1 [Note (2)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only. The maximum use temperature is 842°F.

Table 5M
Maximum Allowable Stress Values — Section VIII, Division 2, Class 1

For Metal Temperature Not Exceeding, °C	Seamless Tube; Sheet, Strip, and Plate <6.35 mm		Seamless Pipe		Plate ≥6.35 mm and Bar	
	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]
40	250	250	251	251	234	234
65	249	250	234	251	206	234
100	230	248	217	248	191	232
150	213	237	200	237	176	222
200	201	229	189	229	166	215
250	192	224	180	224	158	210
300	184	220	173	220	152	205
350	177	216	166	217	146	197
400	171	213	161	213	142	191
450	168	208	158	209	139	188

NOTE: (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 6
Maximum Allowable Stress Values — Section VIII, Division 2, Class 2

For Metal Temperature Not Exceeding, °F	Seamless Tube; Sheet, Strip, and Plate <0.25 in.		Seamless Pipe		Plate ≥0.25 in. and Bar	
	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]
75	41.1	41.1	38.7	38.7	34.0	34.0
100	41.1	41.1	38.7	38.7	34.0	34.0
200	33.8	41.1	31.8	38.7	28.0	34.0
300	30.9	41.1	29.1	38.7	25.6	34.0
400	29.0	39.1	27.3	36.8	24.0	32.4
500	27.5	37.2	25.9	35.0	22.8	30.8
600	26.3	35.5	24.7	33.4	21.8	29.4
700	25.3	34.1	23.8	32.1	20.9	28.2
800	24.6	33.1	23.1	31.2	20.3	27.4
900	24.2 [Note (2)]	32.7 [Note (2)]	22.8 [Note (2)]	30.8 [Note (2)]	20.0 [Note (2)]	27.1 [Note (2)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only. The maximum use temperature is 842°F.

Table 6M
Maximum Allowable Stress Values — Section VIII, Division 2, Class 2

For Metal Temperature Not Exceeding, °C	Seamless Tube; Sheet, Strip, and Plate <6.35 mm		Seamless Pipe		Plate ≥6.35 mm and Bar	
	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]
40	283	283	267	267	234	234
65	249	283	234	267	206	234
100	230	283	217	267	191	234
150	213	283	200	267	176	234
200	201	271	189	255	166	224
250	192	259	180	243	158	214
300	184	248	173	233	152	205
350	177	239	166	224	146	197
400	171	231	161	218	142	191
450	168	227	158	213	139	188

NOTE: (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 7
Yield Strength, Y-1, and Tensile Strength, U, Values

(E)

For Metal Temperature Not Exceeding, °F	Seamless Tube; Sheet, Strip, and Plate <0.25 in.		Seamless Pipe		Plate ≥0.25 in. and Bar	
	Yield Strength Values, ksi [Note (1)]	Tensile Strength Values, ksi [Note (2)]	Yield Strength Values, ksi	Tensile Strength Values, ksi [Note (1)]	Yield Strength Values, ksi [Note (1)]	Tensile Strength Values, ksi [Note (2)]
75	61.6	108.8	58.0	109.0	51.0	102.0
100	61.6	108.8	58.0	109.0	51.0	102.0
200	50.8	108.6	47.8	108.8	42.0	101.8
300	46.4	103.1	43.6	103.3	38.4	96.6
400	43.5	99.4	40.9	99.6	36.0	93.2
500	41.3	96.9	38.9	97.1	34.2	90.9
600	39.4	95.1	37.1	95.3	32.6	89.1
700	37.9	93.4	35.7	93.6	31.4	87.6
800	36.8	91.6	34.7	91.8	30.5	85.9
900	36.3	89.2	34.2	89.4	30.1	83.6

NOTES:

(1) See Section II, Part D, Table Y-1, General Note (b).

(2) See Section II, Part D, Table U, General Note (b).

Table 7M
Yield Strength, Y-1, and Tensile Strength, U, Values

(E)

For Metal Temperature Not Exceeding, °C	Seamless Tube; Sheet, Strip, and Plate <6.35 mm		Seamless Pipe		Plate ≥6.35 mm and Bar	
	Yield Strength Values, MPa [Note (1)]	Tensile Strength Values, MPa [Note (2)]	Yield Strength Values, MPa	Tensile Strength Values, MPa [Note (1)]	Yield Strength Values, MPa [Note (1)]	Tensile Strength Values, MPa [Note (2)]
40	425	750	400	751	352	703
65	373	750	351	751	309	703
100	346	743	325	745	286	697
150	319	710	300	711	264	666
200	301	687	283	688	249	644
250	287	671	270	672	238	629
300	275	659	259	660	228	618
350	265	648	249	650	219	608
400	257	639	242	639	213	598
450	252	625	237	626	208	586

NOTES:

(1) See Section II, Part D, Table Y-1, General Note (b).

(2) See Section II, Part D, Table U, General Note (b).

Table 8
Thermal Expansion

Temperature Range, °F	Value, in./in./°F × 10 ⁻⁶
86-122	7.28
86-212	7.81
86-302	8.02
86-392	8.15
86-482	8.26
86-572	8.37
86-662	8.47
86-752	8.56
86-842	8.64

Table 8M
Thermal Expansion

Temperature Range, °C	Value, mm/mm/°C × 10 ⁻⁶
30-50	13.1
30-100	14.1
30-150	14.4
30-200	14.7
30-250	14.9
30-300	15.1
30-350	15.2
30-400	15.4
30-450	15.6

Table 9
Thermal Conductivity and Thermal Diffusivity

Temperature, °F	Thermal Conductivity, Btu/hr ft °F	Thermal Diffusivity, ft ² /hr
73	5.84	0.110
122	6.19	0.113
212	6.82	0.120
302	7.40	0.126
392	7.92	0.133
482	8.38	0.138
572	8.90	0.145
662	9.42	0.150
752	9.94	0.157
842	10.50	0.162

Table 9M
Thermal Conductivity and Thermal Diffusivity

Temperature, °C	Thermal Conductivity, W/m°C	Thermal Diffusivity, m ² /s × 10 ⁻⁶
23	10.1	2.83
50	10.7	2.92
100	11.8	3.09
150	12.8	3.26
200	13.7	3.42
250	14.5	3.57
300	15.4	3.73
350	16.3	3.88
400	17.2	4.04
450	18.1	4.18

Table 10
Modulus of Elasticity and Poisson's Ratio

Temperature, °F	Modulus of Elasticity, ksi × 10 ³	Poisson's Ratio
68	27.8	0.291
122	27.6	0.292
212	27.1	0.294
302	26.6	0.296
392	26.2	0.298
482	25.7	0.300
572	25.2	0.302
662	24.8	0.304
752	24.3	0.306
842	23.8	0.308

Table 10M
Modulus of Elasticity and Poisson's Ratio

Temperature, °C	Modulus of Elasticity, MPa × 10 ³	Poisson's Ratio
20	192	0.291
50	190	0.292
100	187	0.294
150	184	0.296
200	180	0.298
250	177	0.300
300	174	0.302
350	171	0.304
400	168	0.306
450	164	0.308

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Case 2983

Solution Annealed Ni–Cr–Mo UNS N06058 Alloy Wrought Fittings, Forgings, Bar, Plate, Sheet, Strip, Welded Pipe, Seamless Pipe and Tube, and Welded Tube for Class 1

Section VIII, Division 1; Section VIII, Division 2

Approval Date: December 2, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed Ni–Cr–Mo Alloy (UNS N06058) wrought fittings, forgings, bar, plate, sheet, strip, welded pipe, seamless pipe and tube, and welded tube conforming to the requirements of Specifications listed in [Table 1](#) be used in welded construction under the rules of Section VIII, Division 1 and Division 2, Class 1?

Reply: It is the opinion of the Committee that solution annealed Ni–Cr–Mo UNS N06058 material, as described in the Inquiry, may be used in welded construction under the rules of Section VIII, Division 1 and Division 2, Class 1, provided the following additional requirements are met:

(a) The material shall be heat treated at a temperature of 2,105°F to 2,155°F (1 150°C to 1 185°C) followed by a rapid cooling in air or water.

(b) For Section VIII, Division 1 application, the rules of Subsection C, Part UNF for nickel alloys shall apply. For Section VIII, Division 2, Class 1 application, the rules for nickel alloys shall apply.

(c) The yield strength and tensile strength values for use in design shall be as given in [Tables 2](#) and [2M](#).

(d) The maximum allowable stress values for the material shall be those given in [Tables 3](#) and [3M](#). For welded pipe, tube, or fittings products, a joint efficiency factor of 0.85 shall be used.

(e) The maximum design temperature is 842°F (450°C).

(f) For external pressure design, Section II, Part D, Figure NFN-14 shall be used.

(g) The physical properties for UNS N06058 are given in [Tables 4](#) and [4M](#) for density, thermal diffusivity, thermal conductivity, dynamic modulus of elasticity, mean coefficient of thermal expansion, and Poisson's ratio.

(h) Separate welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(i) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of [\(a\)](#) shall apply.

(j) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Specifications

Specification	Product Form
ASTM B366/B366M-17	Factory-made wrought nickel and nickel alloy fittings
ASTM B564-17a	Nickel alloy forgings
ASTM B574-17	Nickel alloy rod
ASTM B575-17	Nickel alloy plate, sheet, and strip
ASTM B619/B619M-17b	Welded nickel and nickel cobalt alloy pipe
ASTM B622-17b	Seamless nickel and nickel-cobalt alloy pipe and tube
ASTM B626-17a	Welded nickel and nickel-cobalt alloy tube

Table 2
Yield Strength, S_y , and Tensile Strength, S_u , Values

For Metal Temperature Not Exceeding, °F	Yield Strength, S_y , Values, ksi [Note (1)]	Tensile Strength, S_u , Values, ksi [Note (2)]
100	52.2	110.2
200	46.9	110.2
300	42.8	110.2
400	39.0	109.2
500	36.0	105.0
600	33.9	102.6
650	33.1	101.9
700	32.6	101.6
750	32.2	101.5
800	32.0	101.3
850 [Note (3)]	31.9	101.0

NOTES:

- (1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).
- (2) See Section II, Part D, Subpart 1, Table U, General Note (b).
- (3) These values are provided for interpolation purposes only. The maximum design temperature of this material is 842°F.

Table 2M
Yield Strength, S_y , and Tensile Strength, S_u , Values

For Metal Temperature Not Exceeding, °C	Yield Strength, S_y , Values, MPa [Note (1)]	Tensile Strength, S_u , Values, MPa [Note (2)]
40	360	760
65	338	760
100	320	760
125	307	760
150	294	760
175	282	760
200	271	755
225	261	741
250	252	729
275	244	718
300	237	711
325	232	705
350	227	702
375	224	700
400	222	700
425	221	699
450	220	697

NOTES:

- (1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).
- (2) See Section II, Part D, Subpart 1, Table U, General Note (b).

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Division 1 Values, ksi	Division 2, Class 1 Values, ksi
100	31.5, 31.5	34.8, 34.8
200	31.3, 31.5 [Note (1)]	31.3, 34.8 [Note (1)]
300	28.5, 31.5 [Note (1)]	28.5, 34.8 [Note (1)]
400	26.0, 31.2 [Note (1)]	26.0, 34.8 [Note (1)]
500	24.0, 30.0 [Note (1)]	24.0, 32.4 [Note (1)]
600	22.6, 29.3 [Note (1)]	22.6, 30.5 [Note (1)]
650	22.1, 29.1 [Note (1)]	22.1, 29.8 [Note (1)]
700	21.7, 29.0 [Note (1)]	21.7, 29.3 [Note (1)]
750	21.5, 29.0 [Note (1)]	21.5, 29.0 [Note (1)]
800	21.3, 28.8 [Note (1)]	21.3, 28.8 [Note (1)]
850 [Note (2)]	21.3, 28.7 [Note (1)]	21.3, 28.7 [Note (1)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only. The maximum design temperature of this material is 842°F.

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Division 1 Values, MPa	Division 2, Class 1 Values, MPa
40	217, 217	240, 240
65	217, 217	226, 240
100	213, 217 [Note (1)]	213, 240 [Note (1)]
125	205, 217 [Note (1)]	205, 240 [Note (1)]
150	196, 217 [Note (1)]	196, 240 [Note (1)]
175	188, 217 [Note (1)]	188, 240 [Note (1)]
200	181, 216 [Note (1)]	181, 240 [Note (1)]
225	174, 212 [Note (1)]	174, 235 [Note (1)]
250	168, 208 [Note (1)]	168, 227 [Note (1)]
275	163, 205 [Note (1)]	163, 219 [Note (1)]
300	158, 203 [Note (1)]	158, 213 [Note (1)]
325	154, 202 [Note (1)]	154, 208 [Note (1)]
350	152, 201 [Note (1)]	152, 205 [Note (1)]
375	149, 200 [Note (1)]	149, 202 [Note (1)]
400	148, 200 [Note (1)]	148, 200 [Note (1)]
425	147, 199 [Note (1)]	147, 199 [Note (1)]
450	147, 198 [Note (1)]	147, 198 [Note (1)]

NOTE: (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 4
Physical Properties

Temperature, °F	Density, lb/in. ³	Thermal Diffusivity, ft ² /hr	Thermal Conductivity, Btu/hr-ft-°F	Dynamic Modulus of Elasticity, ×10 ⁶ psi	Mean Coefficient of Thermal Expansion 78°F to Temp., ×10 ⁻⁶ in./in./°F
Room	0.311	0.103	5.5	29.5	...
100	...	0.105	5.7	29.5	6.3
200	...	0.113	6.3	29.0	6.4
300	...	0.121	6.9	28.6	6.6
400	...	0.130	7.5	28.1	6.7
500	...	0.138	8.2	27.6	6.9
600	...	0.147	8.8	27.2	7.0
700	...	0.155	9.4	26.7	7.1
800	...	0.163	10.0	26.2	7.2
900	...	0.172	10.7	25.8	7.3

GENERAL NOTE: Poisson's Ratio = 0.33

Table 4M
Physical Properties

Temperature, °C	Density, kg/m ³	Thermal Diffusivity, ×10 ⁻⁶ m ² /sec	Thermal Conductivity, W/(m-°C)	Dynamic Modulus of Elasticity, ×10 ³ MPa	Mean Coefficient of Thermal Expansion 25°C to Temp., ×10 ⁻⁶ mm/mm/°C
Room	8601	2.66	9.5	204	...
50	...	2.75	9.8	203	11.4
100	...	2.95	11.1	200	11.6
150	...	3.14	12.1	197	11.9
200	...	3.32	13.0	194	12.1
250	...	3.53	14.0	191	12.3
300	...	3.74	15.0	188	12.5
350	...	3.94	16.0	185	12.7
400	...	4.14	16.9	182	12.9
450	...	4.31	17.7	180	13.0

GENERAL NOTE: Poisson's Ratio = 0.33

Case 2984-1

18Cr-11Ni-3Cu-Mo-Nb-B-N Austenitic Stainless Steel, UNS S34752

Section I; Section VIII, Division 1

Approval Date: February 8, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 18Cr-11Ni-3Cu-Mo-Nb-B-N austenitic stainless steel (UNS S34752) forging, plate, pipe, tube, fittings, and bar, meeting the chemical composition and mechanical property requirements shown in Tables 1 and 2, and otherwise conforming to one of the specifications given in Table 3, be used in welded construction under the rules of Section I and Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section I and Section VIII, Division 1 construction provided the following additional requirements are met:

(a) For Section VIII, Division 1 construction, the rules in Section VIII, Division 1, Subsection C that shall apply are those in Part UHA for austenitic stainless steels.

(b) For external pressure design, use Section II, Part D, Figure HA-4.

(c) The maximum allowable stress values for the material shall be those given in Tables 4 and 4M. For welded pipe and fitting products, a joint efficiency factor of 0.85 shall be used.

(d) Maximum design temperature of the material shall be 1,500°F (816°C).

(e) Separate welding procedure qualifications shall be conducted for the material in accordance with Section IX.

(f) For welder performance qualifications, this material shall be considered as being P-No. 8.

(g) For Section I construction, the rules of PG-19 for Grade 347 shall apply for this material, except that solution treatment, when required, shall be in the range of 1,940°F to 2,138°F (1 060°C to 1 170°C) followed by rapid cooling in air or water; and the y values (see Section I, PG-27.4.6) shall be as follows:

(1) 1,050°F (565°C) and below: 0.4

(2) 1,100°F (595°C): 0.5

(3) 1,150°F (620°C) and above: 0.7

(h) For Section VIII, Division 1 construction, heat treatment shall be performed at a temperature range from 1,940°F to 2,138°F (1 060°C to 1 170°C) followed by

rapid cooling in air or water, when the fabrication strain exceeds the following limits:

(1) 15% when the design temperature exceeds 1,000°F (540°C) but less than or equal to 1,250°F (675°C).

(2) 10% when the design temperature exceeds 1,250°F (675°C).

(i) The material shall be furnished in the solution annealed condition at a temperature range of 1,940°F to 2,138°F (1 060°C to 1 170°C) followed by rapid cooling in air or water.

(j) This Case number shall be shown on the documentation and marking of the material and shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.005-0.02
Manganese, max.	2.00
Phosphorus, max.	0.035
Sulfur, max.	0.01
Silicon, max.	0.60
Chromium	17.0-19.0
Nickel	10.0-13.0
Copper	2.50-3.50
Molybdenum	0.20-1.20
Niobium	0.20-0.50
Boron	0.001-0.005
Nitrogen	0.06-0.12
Niobium/Carbon ratio, min.	15
Iron	Balance

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength, min., ksi (MPa)	75 (515)
Yield strength, 0.2% offset min., ksi (MPa)	30 (205)
Elongation in 2 in. (50 mm), min., %	35

**Table 3
Product Specifications**

Product	Specification
Bars	SA-479
Fittings	SA-403
Forgings	SA-182/SA-182M
Pipes	SA-312/SA-312M
Plate	SA-240/SA-240M
Tubes	SA-213/SA-213M
Welded pipe	SA-358

**Table 4
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
75	19.8, 19.8
100	19.2, 19.8 [Note (1)]
200	17.6, 19.8 [Note (1)]
300	16.7, 19.8 [Note (1)]
400	16.1, 19.0 [Note (1)]
500	15.5, 18.3 [Note (1)]
600	14.8, 17.9 [Note (1)]
650	14.5, 17.8 [Note (1)]
700	14.2, 17.8 [Note (1)]
750	13.8, 17.8 [Note (1)]
800	13.5, 17.7 [Note (1)]
850	13.2, 17.7 [Note (1)]
900	12.9, 17.5 [Note (1)]
950	12.7, 17.2 [Note (1)]
1,000	12.5, 16.9 [Note (1)]
1,050	12.4, 16.8 [Note (1)]
1,100	12.3, 16.7 [Note (1)]
1,150	12.3, 14.0 [Note (1)], [Note (2)]
1,200	10.6, 10.6 [Note (2)]
1,250	7.9, 7.9 [Note (2)]
1,300	5.9, 5.9 [Note (2)]
1,350	4.3, 4.3 [Note (2)]
1,400	3.1, 3.1 [Note (2)]
1,450	2.2, 2.2 [Note (2)]
1,500	1.5, 1.5 [Note (2)]

NOTES:

- (1) See Section II, Part D, Table 1A, Note G5.
- (2) These values are obtained from time-dependent properties. See Section II, Part D, Table 1A, Note T9.

**Table 4M
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
21	137, 137
40	131, 137 [Note (1)]
65	126, 137 [Note (1)]
100	121, 137 [Note (1)]
125	118, 137 [Note (1)]
150	115, 137 [Note (1)]
175	113, 135 [Note (1)]
200	111, 132 [Note (1)]
225	109, 129 [Note (1)]
250	107, 127 [Note (1)]
275	106, 125 [Note (1)]
300	104, 124 [Note (1)]
325	102, 123 [Note (1)]
350	99.4, 123 [Note (1)]
375	97.3, 123 [Note (1)]
400	95.2, 122 [Note (1)]
425	93.2, 122 [Note (1)]
450	91.3, 122 [Note (1)]
475	99.6, 121 [Note (1)]
500	88.2, 119 [Note (1)]
525	87.0, 117 [Note (1)]
550	86.1, 116 [Note (1)]
575	85.4, 115 [Note (1)]
600	85.0, 115 [Note (1)]
625	84.8, 92.7 [Note (1)], [Note (2)]
650	72.0, 72.0 [Note (2)]
675	55.5, 55.5 [Note (2)]
700	42.4, 42.4 [Note (2)]
725	32.1, 32.1 [Note (2)]
750	24.1, 24.1 [Note (2)]
775	17.9, 17.9 [Note (2)]
800	13.1, 13.1 [Note (2)]
825	8.7, 8.7 [Note (2)], [Note (3)]

NOTES:

- (1) See Section II, Part D, Table 1A, Note G5.
- (2) These values are obtained from time-dependent properties. See Section II, Part D, Table 1A, Note T9.
- (3) The maximum use temperature is 1,500°F (816°C). The value is provided for interpolation only and is calculated using an F_{avg} of 0.67.

Case 2985

Extending Mandatory Appendix 34 to Use PAW to Weld UNS S32615 Meeting the Requirements of SA-240/SA-240M

Section VIII, Division 1

Approval Date: December 12, 2019

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may plasma arc welding (PAW) be used to weld UNS S32615 meeting the requirements of SA-240/SA-240M for construction under the rules of Section VIII, Division 1, Mandatory Appendix 34?

Reply: It is the opinion of the Committee that plasma arc welding (PAW) may be used to weld UNS S32615 meeting the requirements of SA-240/SA-240M for construction under the rules of Mandatory Appendix 34 of Section VIII, Division 1, provided the following additional requirements are met:

(a) The maximum nominal thickness of the weld for plasma arc welding (PAW) of UNS S32615 shall be limited to 0.32 in. (8 mm).

(b) This Case number shall be identified on the Manufacturer's Data Report.

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Case 2986-1

Capacitor Discharge Welding of Thermocouples to Material Less Than 0.20 in. (5 mm) Minimum Wall Thickness

Section I

Approval Date: July 24, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may capacitive discharge welding be used to attach bare wire thermocouples to the following materials:

- (a) P-No. 1, Group No. 1, 2, and 3
- (b) P-No. 4, Group No. 1 and 2
- (c) P-No. 5A, Group No. 1
- (d) P-No. 5B, Group No. 1
- (e) P-No. 15E, Group No. 1

with a minimum wall thickness of less than 0.20 in. (5.0 mm) without requiring postweld heat treatment in accordance with PW-39?

Reply: It is the opinion of the Committee that capacitive discharge welding may be used to attach bare wire thermocouples to the materials described in the Inquiry with a minimum wall thickness of less than 0.20 in. (5.0 mm) without requiring postweld heat treatment in accordance with PW-39, provided the following requirements are met:

- (a) The requirements for PW-39.8 are met.
- (b) The maximum carbon content of the base material is restricted to 0.15%.
- (c) Prior to using the welding procedure, the Manufacturer shall demonstrate that the heat-affected zone does not encroach upon the minimum wall thickness.
- (d) This Case number shall be shown on the Manufacturer's Data Report or Manufacturer's Partial Data Report for the welded component.

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Case 2987

Use of UNS C12200 ASTM B359/B359M-18 With O62 Temper in the Manufacture of Part HLW Water Heaters and Part HF Boilers

Section IV

Approval Date: January 21, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS C12200 conforming to ASTM B359/B359M-18 with an O62 temper be used in the construction of Section IV, Part HLW water heaters and Part HF boilers?

Reply: It is the opinion of the Committee that UNS C12200 conforming to ASTM B359/B359M-18 with an O62 temper may be used in the construction of Section

IV, Part HLW water heaters and Part HF boilers, provided the following requirements are met:

(a) The allowable stress values shall be as listed in [Tables 1](#) and [1M](#).

(b) For the purposes of welding procedure and performance qualifications, this material shall be considered P-No. 31.

(c) Use under external pressure is prohibited.

(d) All other requirements of Section IV shall apply.

(e) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values
for ASTM B359/B359M, UNS C12200, O62 Temper

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	4.3
150	3.8
200	3.8
250	3.8
300	3.8

Table 1M
Maximum Allowable Stress Values
for ASTM B359/B359M, UNS C12200, O62 Temper

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	29.9
65	26.4
100	26.4
125	26.4
150	26.3

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Case 2988

Use of UNS S31635 (316Ti) Austenitic Stainless Steel in SA-312/SA-312M Seamless and Welded Pipe in the Manufacture of Part HLW Water Heaters and Storage Tanks

Section IV

Approval Date: January 21, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S31635 (316Ti) austenitic stainless steel in form of SA-312/SA-312M seamless and welded pipe be used in the construction of unlined Section IV, Part HLW water heaters and storage tanks?

Reply: It is the opinion of the Committee that UNS S31635 (316Ti) austenitic stainless steel in form of SA-312/SA-312M seamless and welded pipe may be used in the construction of unlined Section IV, Part HLW water heaters and storage tanks, provided the following requirements are met:

(a) The maximum allowable stress values shall be as listed in [Tables 1](#) and [1M](#).

(b) Welding procedure and performance qualification shall be conducted in accordance with Section IX. This material shall be considered P-No. 8, Group No. 1.

(c) For external pressure, Section II, Part D, Figure HA-2 shall be used.

(d) The maximum design temperature shall be 500°F (260°C).

(e) All other applicable requirements of Section IV, Part HLW shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values
for SA-312/SA-312M Seamless and Welded Pipe

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Seamless	Welded
100	18.8	15.9
200	17.7	15.0
300	15.9	13.5
400	14.3	12.2
500	13.2	11.2

GENERAL NOTE: For product in welded form, the allowable stress values have been multiplied by a factor of 0.85.

Table 1M
Maximum Allowable Stress Values
for SA-312/SA-312M Seamless and Welded Pipe

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Seamless	Welded
40	129	110
100	120	102
150	109	92.9
200	99.3	84.4
250	92.0	78.2
275 [Note (1)]	89.3	75.9

GENERAL NOTE: For product in welded form, the allowable stress values have been multiplied by a factor of 0.85.

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

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Case 2989

Use of Alloy SUS304TB Tube in Accordance With JIS G 3463:2012 in the Construction of Heating Boilers Under Part HF

Section IV

Approval Date: January 21, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may Alloy SUS304TB tube meeting the material requirements of JIS G 3463:2012 be used in the construction of heating boilers per Section IV, Part HF?

Reply: It is the opinion of the Committee that Alloy SUS304TB tube meeting the material requirements of JIS G 3463:2012 may be used in the construction of heating boilers under Section IV, provided the following requirements are met:

(a) The allowable stress values for Alloy SUS304TB shall be as listed in [Tables 1](#) and [1M](#).

(b) The minimum tensile strength shall be 75 ksi (520 MPa).

(c) The minimum yield strength shall be 30 ksi (205 MPa).

(d) For the purpose of welding and brazing procedures and performance qualifications, this material shall be considered P-No. 8, Group 1.

(e) For external pressure, Section II, Part D, Figure HA-1 shall be used.

(f) Minimum wall thickness of tube shall not be less than 0.020 in. (0.5 mm) and the outside diameter shall not exceed 0.980 in. (24.9 mm).

(g) Flattening or flaring tests as defined in JIS G 3463:2012, para. 11.2.4 or para. 11.2.5 shall be made on all tube including seamless tube.

(h) Welded tube shall be tested in accordance with the requirements and methods for reverse flattening tests as defined in JIS G 3463:2012, para. 11.2.6.

(i) The tube shall be made by a seamless process, laser welding, electric resistance welding, or by an automatic welding process with no addition of filler metal in the welding operation.

(j) All tubes shall be subjected to a heat treatment by the manufacturer as specified in JIS G 3463:2012, para. 4b) and Table 2, Heat Treatment. The finished tube shall be free of oxide film. Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of JIS G 3463:2012, Table 2 shall apply.

(k) The elongation values in [Tables 2](#) and [3](#) shall apply.

(l) The materials manufacturer or vendor shall submit an inspection certificate (Reference JIS G 3463:2012, clauses 12 and 14) to the purchaser with a statement that the tube has been manufactured, inspected, and tested in accordance with the requirements of the JIS specification and this Case.

(m) The materials manufacturer or vendor shall identify the material being provided. The identification shall be traceable to the inspection certificate.

(n) All other requirements of Section IV shall apply.

(o) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	15.0
150	15.0
200	14.2
250	13.6
300	13.2
350	13.0
400	12.8
450	12.7
500	12.7

GENERAL NOTE: For welded tube, the stress values listed in this table shall be multiplied by a weld joint factor of 0.85.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	103
65	103
100	96.9
125	93.6
150	91.2
175	89.5
200	88.4
225	87.7
250	87.5
275 [Note (1)]	87.4

GENERAL NOTE: For welded tube, the stress values listed in this table shall be multiplied by a weld joint factor of 0.85.

NOTE: (1) The maximum allowable use temperature is 260°C. The value for 275°C is provided for interpolation only.

Table 2
Elongation, %, For SUS304TB Tube Based on Outside Diameter

Test Piece Per JIS Z 2241:2011	Outside Diameter		
	Less Than 0.394 in. (10 mm)	0.394 in. (10 mm) or Over to Less Than 0.787 in. (20 mm)	0.787 in. (20 mm) or Over
No. 11 Tube form	27% min.	30% min.	35% min.
No. 12 Strip form [Note (1)]	...	...	35% min.

NOTE: (1) See Table 3.

Table 3
Elongation, %, For SUS304TB Tube With Less Than 0.315 in. (8 mm) Wall Thickness When Tensile Test Is Performed Using No. 12 Strip-Form Test Piece

Test Piece Per JIS Z 2241:2011	Wall Thickness						
	>0.039 in. (>1 mm) Up to 0.079 in. (2 mm)	>0.079 in. (>2 mm) Up to 0.118 in. (3 mm)	>0.118 in. (>3 mm) Up to 0.157 in. (4 mm)	>0.157 in. (>4 mm) Up to 0.197 in. (5 mm)	>0.197 in. (>5 mm) Up to 0.236 in. (6 mm)	>0.236 in. (>6 mm) Up to 0.276 in. (7 mm)	>0.276 in. (>7 mm) But Less Than <0.315 in. (<8 mm)
No. 12 strip-form parallel to axis	26% min.	28% min.	29% min.	30% min.	32% min.	34% min.	35% min.

GENERAL NOTE: When the tensile test is carried out using a No. 12 strip-form test piece from tubes with wall thickness less than 0.315 in. (8 mm), the minimum elongation values in this Table shall apply.

Case 2990

Use of EN 10216-3:2013, Grade P460NL1, Fine-Grain Seamless Steel Tubes

Section VIII, Division 1

Approval Date: March 13, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may fine-grain seamless steel tubes, manufactured in accordance with EN 10216-3:2013, Grade P460NL1 be used in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that fine-grain seamless steel tubes manufactured in accordance with EN 10216-3:2013, Grade P460NL1, may be used in Section VIII, Division 1 construction, provided the following requirements are met:

(a) The material shall be ordered and certified as cold finished, normalized, and as Test Category 2 in accordance with EN 10216-3:2013.

(b) The thickness of the tube shall not exceed 0.79 in. (20 mm).

(c) The maximum internal diameter for the tube shall be 12 in. (305 mm).

(d) The design temperature shall not exceed 176°F (80°C).

(e) The minimum design metal temperature shall not be lower than -40°F (-40°C).

(f) The provisions for impact exemption in UG-20(f) and UCS-66 shall not apply.

(g) No welding shall be performed on this material.

(h) Maximum allowable stress to be used in the design shall be limited to 23.2 ksi (160 MPa).

(i) For external pressure design, the requirements of Section II, Part D, Figure CS-5 shall apply.

(j) All other requirements of Section VIII, Division 1 shall apply, considering this material as UCS material.

(k) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2991

Solution Annealed Ni-Fe-Cr-Mo-Cu Low Carbon Alloy (UNS N08034) Wrought Fittings, Forgings, Bar, Plate, Sheet, Strip, Welded Pipe, Seamless Pipe and Tube, and Welded Tube for Class 1

Section VIII, Division 1; Section VIII, Division 2

Approval Date: March 13, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed Ni-Fe-Cr-Mo-Cu low carbon alloy (UNS N08034) wrought fittings, forgings, bar, plate, sheet, strip, welded pipe, seamless pipe and tube, and welded tube conforming to the requirements of specifications listed in [Table 1](#) be used in welded construction under the rules of Section VIII, Division 1 and Division 2, Class 1?

Reply: It is the opinion of the Committee that Ni-Fe-Cr-Mo-Cu low carbon alloy (UNS N08034) material, as described in the Inquiry, may be used in welded construction under the rules of Section VIII, Division 1 and Division 2, Class 1, provided the following additional requirements are met:

(a) The material shall be heat treated at a temperature of 2,085°F to 2,135°F (1 140°C to 1 170°C) followed by a rapid cooling in air or water.

(b) For Section VIII, Division 1 application, the rules of Subsection C, Part UNF for nickel alloys shall apply. For Section VIII, Division 2, Class 1 application, the rules for nickel alloys shall apply.

(c) The yield strength and tensile strength values for use in design shall be as given in [Tables 2](#) and [2M](#).

(d) The maximum allowable stress values for the material shall be those given in [Tables 3](#) and [3M](#). For welded pipe, tube, or fittings products, a joint efficiency factor of 0.85 shall be used.

(e) The maximum design temperature is 842°F (450°C).

(f) For external pressure design, Section II, Part D, Figure NFN-11 shall be used.

(g) The physical properties for UNS N08034 shall be as follows:

(1) thermal diffusivity, thermal conductivity, dynamic modulus of elasticity, mean coefficient of thermal expansion as given in [Tables 4](#) and [4M](#).

(2) density: 0.292 lb/in.³ (8076 kg/m³)

(3) Poisson's ratio: 0.31

(h) Separate welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(i) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of (a) shall apply.

(j) This Case number shall be shown on the marking and documentation and the Manufacturer's Data Report.

Table 1
Specifications

Specification	Product Form
ASTM B564-17a	Nickel alloy forgings
ASTM B581-17	Nickel alloy rod
ASTM B619/B619M-17b	Welded nickel and nickel cobalt alloy pipe
ASTM B622-17b	Seamless nickel and nickel-cobalt alloy pipe and tube
ASTM B625-17	Nickel alloy plate, sheet, and strip
ASTM B626-17a	Welded nickel and nickel-cobalt alloy tube

Table 2
Yield Strength, S_y , and Tensile Strength, S_u , Values

For Metal Temperature Not Exceeding, °F	Yield Strength, S_y , Values, ksi [Note (1)]	Tensile Strength, S_u , Values, ksi [Note (2)]
100	40.0	94.0
200	34.1	94.0
300	30.7	90.3
400	28.1	86.3
500	26.3	83.0
600	25.0	80.3
650	24.6	79.0
700	24.2	77.8
750	24.0	76.6
800	23.8	75.4
850 [Note (3)]	23.7	74.3

NOTES:

- (1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).
- (2) See Section II, Part D, Subpart 1, Table U, General Note (b).
- (3) These values are provided for interpolation purposes only. The maximum design temperature of this material is 842°F.

Table 2M
Yield Strength, S_y , and Tensile Strength, S_u , Values

For Metal Temperature Not Exceeding, °C	Yield Strength, S_y , Values, MPa [Note (1)]	Tensile Strength, S_u , Values, MPa [Note (2)]
40	276	648
65	249	648
100	232	648
125	221	637
150	211	622
175	202	609
200	195	597
225	188	586
250	183	576
275	178	567
300	175	558
325	171	550
350	169	543
375	167	535
400	165	528
425	164	521
450	163	513

NOTES:

- (1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).
- (2) See Section II, Part D, Subpart 1, Table U, General Note (b).

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Division 1 Values, ksi	Division 2, Class 1 Values, ksi
100	26.7, 26.7	26.7, 26.7
200	22.7, 26.7 [Note (1)]	22.7, 26.7 [Note (1)]
300	20.4, 25.8 [Note (1)]	20.4, 26.7 [Note (1)]
400	18.7, 24.7 [Note (1)]	18.7, 25.3 [Note (1)]
500	17.5, 23.6 [Note (1)]	17.5, 23.6 [Note (1)]
600	16.7, 22.5 [Note (1)]	16.7, 22.5 [Note (1)]
650	16.4, 22.1 [Note (1)]	16.4, 22.1 [Note (1)]
700	16.2, 21.8 [Note (1)]	16.2, 21.8 [Note (1)]
750	16.0, 21.6 [Note (1)]	16.0, 21.6 [Note (1)]
800	15.9, 21.4 [Note (1)]	15.9, 21.4 [Note (1)]
850 [Note (2)]	15.8, 21.2 [Note (1)]	15.8, 21.3 [Note (1)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only. The maximum design temperature of this material is 842°F.

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Division 1 Values, MPa	Division 2, Class 1 Values, MPa
40	184, 184	184, 184
65	166, 184 [Note (1)]	166, 184 [Note (1)]
100	154, 184 [Note (1)]	154, 184 [Note (1)]
125	147, 182 [Note (1)]	147, 184 [Note (1)]
150	141, 178 [Note (1)]	141, 184 [Note (1)]
175	135, 174 [Note (1)]	135, 182 [Note (1)]
200	130, 171 [Note (1)]	130, 175 [Note (1)]
225	126, 168 [Note (1)]	126, 170 [Note (1)]
250	122, 165 [Note (1)]	122, 165 [Note (1)]
275	119, 161 [Note (1)]	119, 161 [Note (1)]
300	116, 157 [Note (1)]	116, 157 [Note (1)]
325	114, 154 [Note (1)]	114, 154 [Note (1)]
350	113, 152 [Note (1)]	113, 152 [Note (1)]
375	111, 150 [Note (1)]	111, 150 [Note (1)]
400	110, 149 [Note (1)]	110, 149 [Note (1)]
425	109, 148 [Note (1)]	109, 148 [Note (1)]
450	109, 147 [Note (1)]	109, 147 [Note (1)]

NOTE: (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

**Table 4
Physical Properties**

Temperature, °F	Thermal Diffusivity, ft ² /hr	Thermal Conductivity, Btu/hr-ft-°F	Dynamic Modulus of Elasticity, ×10 ⁶ psi	Mean Coefficient of Thermal Expansion 68°F to Temp., ×10 ⁻⁶ in./in./°F
Room	0.114	6.0	28.9	...
100	0.117	6.1	28.7	8.1
200	0.124	6.7	28.3	8.2
300	0.132	7.2	27.8	8.4
400	0.138	7.8	27.4	8.6
500	0.146	8.3	26.7	8.8
600	0.153	8.7	26.1	8.9
700	0.160	9.2	25.5	9.0
800	0.166	9.6	24.9	9.1
900	0.173	10.1	24.5	9.1

**Table 4M
Physical Properties**

Temperature, °C	Thermal Diffusivity, ×10 ⁻⁶ m ² /sec	Thermal Conductivity, W/(m-°C)	Dynamic Modulus of Elasticity, ×10 ³ MPa	Mean Coefficient of Thermal Expansion 20°C to Temp., ×10 ⁻⁶ mm/mm/°C
Room	2.94	10.3	199	...
50	3.04	10.8	198	14.7
100	3.23	11.6	195	14.8
150	3.40	12.5	192	15.1
200	3.57	13.4	189	15.4
250	3.73	14.1	185	15.7
300	3.89	14.9	181	16.0
350	4.05	15.6	178	16.2
400	4.21	16.3	174	16.3
450	4.36	17.0	171	16.3

Case 2993

Allowing Nameplates With Thinner Nominal Thickness

Section IV

Approval Date: March 13, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the nameplate be made of a material with thinner nominal thickness than required by HG-530.1 and HLW-602.3?

Reply: It is the opinion of the Committee that the nameplate may be made of a material with thinner nominal thickness than required by HG-530.1 and HLW-602.3, provided the following requirements are met:

(a) The nameplate thickness shall be sufficient to resist distortion due to the application of the marking and to be compatible with the method of attachment.

(b) The nameplate nominal thickness shall not be less than 0.020 in. (0.5 mm).

(c) The nameplate material shall be limited to stainless steels or aluminum.

(d) All other applicable requirements of Section IV shall be met.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 2995

Use of Eccentric Crossings in Construction

Section I

Approval Date: April 2, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may eccentric crossings (see [Figure 1](#)) be used in Section I construction?

Reply: It is the opinion of the Committee that eccentric crossings may be used in Section I construction, provided the following requirements are met:

(a) The design shall be qualified according to PG-16.1. This shall include appropriate analytical methods, such as Design by Analysis, using allowable stresses as defined in PG-23, and calculations of applicable loadings according to PG-22. Detailed documentation shall be available for review and acceptance.

(b) The size of fillet welds, at the top of the groove weld, at the outer side of the eccentric crossings shall be according to PW-16.1.

(c) Application shall be limited to a range of 3.5 in. to 16 in. (88.9 mm to 406.4 mm) pipe outside diameter.

(d) Application shall be limited to P-No. 1 seamless materials only.

(e) The angle of the crossing pipes shall be nominally 90 deg and may not deviate more than fabrication tolerances specified by the manufacturer.

(f) The nominal eccentricity of the pipe center lines shall be $\frac{1}{2}$ of the O.D. of the larger pipe and within the fabrication tolerances specified by the manufacturer.

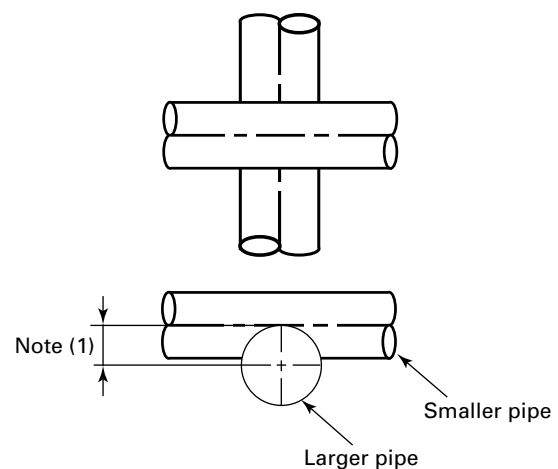
(g) The GTAW process shall be used for welding of the root to provide complete penetration.

(h) The inside surface of the welded root shall be inspected visually or by other suitable means prior to the attachment of the end closures. Visual examination shall be performed in accordance with the requirements described in PG-75 to provide verification that the design and WPS requirements are being met. In addition, visual examination shall be performed to verify that all completed welds comply with the acceptance standards specified below.

The following indications are unacceptable:

- (1) cracks.
- (2) undercut on the surface that is greater than $\frac{1}{32}$ in. (0.8 mm) deep or encroaches on the minimum required section thickness.
- (3) lack of fusion on surface.
- (4) incomplete penetration.
- (5) any other linear indications greater than $\frac{3}{16}$ in. (5.0 mm) long.
- (6) surface porosity with rounded indications having dimensions greater than $\frac{3}{16}$ in. (5.0 mm) or 4 or more rounded indications separated by $\frac{1}{16}$ in. (1.5 mm) or less edge-to-edge in any direction. Rounded indications are indications that are circular or elliptical with their length less than 3 times their width.
- (i) Either magnetic particle examination in accordance with Nonmandatory Appendix A, A-260, or liquid penetrant examination in accordance with A-270 is required for the outer surface of welded eccentric crossings.
- (j) All other applicable requirements of Section I shall apply.
- (k) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Illustration of Eccentric Crossing



NOTE: (1) Nominal eccentricity = $\frac{1}{2}$ O.D. of larger pipe.

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Case 2996-1*

Extension of Joining Personnel's Qualification Continuity

Section I; Section IV; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX; Section XII; Section III, Division 1; Section III, Division 2; Section III, Division 3; Section III, Division 5; Section XI, Division 1; B31

Approval Date: July 15, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an organization extend the qualification continuity of joining personnel?

Reply: It is the opinion of the Committee that the qualification continuity of joining personnel who have experienced an employment interruption due to the COVID-19

outbreak may be extended an additional three months beyond that allowed by QW-322, QB-322, and QF-332, provided the following requirements are met:

(a) The qualification was valid at the time of the employment interruption.

(b) The qualification was scheduled to expire during the employment interruption.

The latest date the joining personnel uses the process within the extended period will be the new date for continuity purposes. QW-322.1(b), QB-322(b), and QF-322.1(b) shall still apply for the joining personnel whose continuity has been extended. The provisions of this Case will expire three months after the approval date.

This Case number shall be shown in the joining personnel's continuity report.

* Corrected by errata, ASME BPVC.CC.BPV.S1-2021, September 2021.

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Case 2998-1

SA-487/SA-487M Grade CA6NM Class A

Section VIII, Division 2

Approval Date: September 15, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May high alloy ferrous steel casting conforming to SA-487/SA-487M Grade CA6NM Class A be used in nonwelded construction under Section VIII, Division 2?

Reply: It is the opinion of the Committee that the steel castings described in the Inquiry may be used in Section VIII, Division 2, nonwelded construction, provided the following requirements are met:

(a) The design temperature shall not exceed 204°C (400°F).

(b) The maximum allowable stress values shall be as shown in Table 1 or Table 1M.

(c) The maximum severity levels for castings shall be as defined in Section VIII, Division 2, para. 3.8.2.2.

(d) The external pressure chart shall be Section II, Part D, Figure CS-5.

(e) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress

For Temperatures Not Exceeding, °F	Maximum Allowable Stress, ksi	
	Class 1	Class 2
100	36.7	45.8
150	36.7	45.8
200	36.7	45.8
250	[Note (1)]	45.8
300	36.0	45.8
350	[Note (1)]	45.8
400	35.1	45.8

NOTE: (1) No value is provided as per Section II, Part D, Table 2A (Class 1).

Table 1M
Maximum Allowable Stress

For Temperatures Not Exceeding, °C	Maximum Allowable Stress, MPa	
	Class 1	Class 2
40	253	316
100	253	316
150	248	316
200	242	316
225 [Note (1)]	[Note (2)]	316
250 [Note (1)]	238	[Note (3)]

NOTES:

(1) Values are for interpolation only; the maximum design temperature is per (a).

(2) No value is provided as per Section II, Part D, Table 2A (Class 1).

(3) No value required; see [Note (1)].

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Case 3000

Tack Welds on Heat Transfer Plates Left In-Place Without Qualification, UW-31(c)

Section VIII, Division 1

Approval Date: June 4, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what circumstances is it permissible to leave tack welds, which are used to secure alignment on heat transfer plates, in place without qualification of the tack weld procedure or the welding operator to Section IX?

Reply: It is the opinion of the Committee that tack welds, which are used to secure alignment on heat transfer plates, may be left in place without qualification of the tack weld

procedure or the welding operator to Section IX, provided that all of the following requirements are met:

(a) The tack weld shall be performed by an automated resistance spot weld process.

(b) The tack weld shall be positioned outside of the pressure boundary and no closer than $2t$ to the pressure boundary, where t = nominal heat transfer plate thickness.

(c) The tack weld shall not be incorporated in any pressure retaining weld.

(d) The maximum heat transfer plate thickness shall be 0.047 in. (1.2 mm).

(e) The energy output shall be limited to 125 W-sec.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3001-1

12Cr-2W-2Co-B Material

Section I

Approval Date: May 12, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 12Cr-2W-2Co-B seamless tubes and pipes conforming to the chemical analysis shown in Table 1, the mechanical properties listed in Table 2, and otherwise conforming to the applicable requirements of SA-213/SA-213M and SA-335/SA-335M be used for Section I construction?

Reply: It is the opinion of the Committee that normalized and tempered seamless 12Cr-2W-2Co-B tubes and pipes as described in the Inquiry may be used for Section I construction, provided the following requirements are met:

(a) The material shall be austenitized within the temperature range 1,975°F to 2,140°F (1080°C to 1170°C) followed by air cooling and tempered within the range 1,400°F to 1,470°F (760°C to 800°C).

(b) The material in the final tempered condition shall not exceed a Brinell Hardness Number of 265 HBW (280 HV).

(c) The maximum design temperature shall be 1,200°F (650°C).

(d) The maximum allowable stress values for the material shall be those given in Table 3 or Table 3M.

(e) Welding shall be limited to GTAW, SMAW, or SAW. Separate weld procedure qualification shall apply for this material. For the purpose of performance qualification, the material shall be considered P-No. 15F. The performance qualification shall be conducted as prescribed in Section IX.

(f) Postweld heat treatment shall be performed between 1,400°F to 1,470°F (760°C to 800°C). The time requirement shall be those given for P-No. 15E, Group 1 materials in Table PW-39-5. Exemptions to postweld heat treatment for this material shall be in accordance with the rules for P-No. 15E materials in Table PW-39-5.

(g) Cold-forming rules for Grade 91 in PG-20 shall apply, except austenitizing and tempering shall be as in (a). Specifically for cold formed flares, swages, and upsets in tubing or pipe, regardless of the dimension

and the amount of cold work, the material shall be re-austenitized and tempered in accordance with (a).

(h) All material formed at or above 1,200°F (650°C) shall be re-austenitized and tempered in accordance with (a). This heat treatment shall not be performed locally. The material shall be either heat treated in its entirety, or the hot formed area (including the transition) shall be cut away from the balance of the tube or component, and heat treated separately or replaced.

(i) Except as provided in (j), if during manufacturing any portion of the component is heated to a temperature greater than 1,470°F (800°C), then the component shall be re-austenitized and retempered in its entirety in accordance with (a), or the portion of the component heated above 1,470°F (800°C), including the heat-affected zone created by the local heating, shall be replaced or shall be removed, renormalized, tempered, and then replaced in the component.

(j) If the allowable stresses to be used are less than or equal to those provided in Section II, Part D, Table 1A for Grade 9 (SA-213/SA-213M T9, SA-335/SA-335M P9) at the design temperature, then the requirements of (i) may be waived, provided that the portion of the component heated to a temperature greater than 1,470°F (800°C) is reheat treated within the temperature range 1,400°F to 1,470°F (760°C to 800°C).

(k) S_u and S_y values are listed in Tables 4 or 4M and Tables 5 or 5M, respectively.

(l) Density shall be 0.282 lb/in.³ (7815 kg/m³). Additional physical properties are shown in Tables 6 and 6M.

(m) External pressure design is prohibited.

(n) This material is a creep strength-enhanced ferritic (CSEF) steel whose creep temperature strength is enhanced by the creation of a precise condition of microstructure, specifically martensite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbonitrides, or other stable and/or metastable phases. Refer to Section I, PW-10 for additional cautionary information.

CSEF alloys may demonstrate a susceptibility to creep-intolerant behavior, which manifests as limited amount of plastic deformation at the time of creep-rupture.

(o) This Case number shall be referenced in the documentation and marking of the material and shall be shown on the Manufacturer's Data Report.

**Table 1
Chemical Requirements**

Element	Composition Limits, %
Carbon	0.12–0.17
Manganese	0.30–0.80
Phosphorus, max.	0.020
Sulphur, max.	0.010
Silicon	0.20–0.60
Chromium	10.50–12.00
Molybdenum	0.20–0.60
Vanadium	0.15–0.30
Nickel	0.10–0.40
Boron	0.008–0.015
Nitrogen	0.002–0.020
Cobalt	1.50–2.20
Aluminum, max.	0.02
Copper, max.	0.15
Tungsten	1.50–2.20
Niobium	0.02–0.06

**Table 2
Mechanical Properties Requirements**

Mechanical Property	Requirement
Tensile strength, min., ksi (MPa)	94.3 (650)
Yield strength, min, ksi (MPa)	71.1 (490)
Elongation in 2 in. (50.8 mm), min., % [Note (1)]	19

NOTE: (1) For longitudinal strip tests, a deduction from the basic values of 1.00% for each $\frac{1}{32}$ in. (0.8 mm) decrease in wall thickness below $\frac{5}{16}$ in. (7.8 mm) shall be made. The following table gives the computed values.

Wall Thickness, in. (mm)	Elongation in 2 in. (50.8 mm), Min., %
0.312 (7.8)	19.0
0.281 (7.1)	18.0
0.250 (6.4)	17.0
0.219 (5.3)	16.0
0.188 (4.8)	15.0
0.156 (4.0)	14.0
0.125 (3.2)	13.0
0.094 (2.4)	12.0
0.062 (1.5)	11.6
0.062 to 0.035 (0.9 to 1.5), excl.	10.9
0.035 to 0.022 (0.6 to 0.9), excl.	10.6
0.022 to 0.015 (0.4 to 0.6), incl.	10.3

GENERAL NOTE: The above table gives the computed minimum elongation values for each $\frac{1}{32}$ in. (0.8 mm) decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value shall be determined by the following equation:

(U.S. Customary Units)

$$E = 32t + 10.0$$

(SI Units)

$$E = 1.25t + 10.0$$

where

E = elongation in 2 in. (50.8 mm), %
 t = actual thickness of specimen, in. (mm)

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
Up to 100	26.9
200	26.9
300	26.7
400	26.0
500	25.5
600	25.0
650	24.6
700	24.2
750	23.6
800	22.9
850	22.0
900	20.9
950	19.7
1,000	18.3
1,050	16.8
1,100	13.2 [Note (1)]
1,150	9.2 [Note (1)]
1,200	5.9 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
Up to 40	186
100	186
200	179
300	173
400	163
425	158
450	153
475	146
500	139
525	131
550	122
575	109 [Note (1)]
600	84.7 [Note (1)]
625	59.9 [Note (1)]
650	39.8 [Note (1)]

NOTE: (1) These values are obtained from time-dependent properties.

Table 4
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °F	Tensile Strength Values, S_u , ksi [Note (1)]
Up to 100	94.3
200	94.3
300	93.3
400	90.9
500	89.2
600	87.4
650	86.2
700	84.7
750	82.7
800	80.1
850	77.0
900	73.3
950	69.0
1,000	64.1
1,050	58.7
1,100	52.9
1,150	46.9
1,200	40.9

NOTE: (1) The tabulated values of tensile strength are those which the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 4M
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °C	Tensile Strength Values, S_u , MPa [Note (1)]
Up to 40	650
65	650
100	650
150	643
200	628
250	617
300	607
325	600
350	592
375	582
400	569
425	554
450	535
475	513
500	487
525	458
550	426
575	391
600	355
625	318
650	281

NOTE: (1) The tabulated values of tensile strength are those which the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 5
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °F	Yield Strength Values, S_y , ksi [Note (1)]
Up to 100	71.1
200	66.9
300	64.7
400	63.2
500	62.1
600	61.0
650	60.3
700	59.4
750	58.2
800	56.7
850	54.8
900	52.4
950	49.6
1,000	46.3
1,050	42.5
1,100	38.1
1,150	33.3
1,200	28.1

NOTE: (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 5M
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °C	Yield Strength Values, S_y , MPa [Note (1)]
Up to 40	490
65	471
100	459
150	446
200	436
250	430
300	423
325	419
350	415
375	409
400	401
425	392
450	380
475	366
500	350
525	330
550	308
575	283
600	255
625	225
650	192

NOTE: (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 6
Physical Properties

Temperature, °F	Modulus of Elasticity, Tension 10 ³ ksi	Thermal Conductivity, Btu/(ft-hr-°F)	Mean CTE, 10 ⁻⁶ in./in./ °F [Note (1)]	Specific Heat, Btu/lb °F	Poisson's Ratio
68	31.7	11.8	...	0.105	0.27
100	31.6	12.1	5.8	0.107	0.27
200	30.9	12.2	5.9	0.113	0.28
300	30.3	12.5	6.0	0.118	0.28
400	29.7	12.8	6.1	0.123	0.28
500	29.1	13.1	6.2	0.127	0.28
600	28.5	13.5	6.3	0.132	0.29
700	27.7	13.8	6.3	0.139	0.29
800	26.9	14.2	6.4	0.146	0.29
900	26.0	14.4	6.5	0.156	0.29
1,000	25.0	14.6	6.6	0.168	0.29
1,100	23.9	14.7	6.7	0.183	0.30
1,200	22.5	14.6	6.8	0.201	0.30
1,300	21.0	14.4	6.8	0.224	0.30

NOTE: (1) Mean CTE values are those from 68°F to indicated temperature.

Table 6M
Physical Properties

Temperature, °C	Modulus of Elasticity, GPa	Thermal Conductivity, W/m K	Mean CTE, 10 ⁻⁶ /K [Note (1)]	Specific Heat, J/kg K	Poisson's Ratio
20	218	20.5	...	441	0.27
50	217	20.9	10.5	454	0.27
100	213	21.5	10.6	473	0.27
150	210	21.9	10.8	491	0.28
200	206	22.2	10.9	510	0.28
250	202	22.5	11.1	529	0.28
300	197	22.9	11.2	550	0.28
350	193	23.4	11.4	571	0.29
400	188	23.8	11.5	595	0.29
450	183	24.7	11.7	627	0.29
500	177	25.5	11.8	675	0.29
550	171	25.9	11.9	718	0.30
600	164	25.5	12.1	766	0.30
650	156	24.9	12.2	835	0.30
700	145	25.1	12.3	938	0.30

NOTE: (1) Mean CTE values are those from 20°C to indicated temperature.

Case 3002

Use of Explosion Welding Process for Tube Plugging

Section IX

Approval Date: July 9, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the explosion welding process be used for tube plugging?

Reply: It is the opinion of the Committee that the explosion welding process may be used for tube plugging, provided the following requirements are met:

1 GENERAL REQUIREMENTS

The requirements below shall only be used to qualify the welding procedure and welding operator, using the explosion welding process for the plugging of tubes, when permitted by the referencing code, standard, or specification.

2 WELDING PROCEDURE QUALIFICATION

(a) The Welding Procedure Specification to be used for tube plugging with the explosion welding process shall be qualified as set forth in QW-200.1 and QW-200.2.

(b) Essential Variables

- (1) a change in the P-Number for any of the materials included in the explosion weld joint, including the tube, plug, tubesheet, and tubesheet cladding when applicable
- (2) if the plug is welded to the tube, a decrease in the nominal tube wall thickness of 10% or more
- (3) a change in the plug wall nominal thickness
- (4) a decrease in the proximity of two plugs to be simultaneously joined by explosion welding
- (5) any increase in the number of plugs to be simultaneously joined by explosion welding
- (6) a change in the type of explosive to be used for welding
- (7) a change of 10% or more in the explosive charge mass to be used for welding
- (8) a decrease of 15% or more in the tubesheet ligament
- (9) a change in the cleanliness requirements for the tube, plug, or hole contact surfaces, including surface oxide removal, prior to explosion welding
- (10) any change in the nominal plug geometry

(11) a change of 10% or more in the clearance (stand-off) between the tube or hole and the plug in the bonding area

(12) the addition or deletion of the use of adjacent hole packing material support bars used to prevent distortion during the welding process

(13) a change in the tubesheet cladding metal, when the explosive charge is installed within one tube diameter of the cladding metal

(14) for tube plugging, a change in the tube-to-tubesheet welding procedure when the explosive charge is installed within one tube diameter of the tube-to-tubesheet weld [see (e)(1)(-c)]

(c) Nonessential Variables

(1) when the plug is not joined to the tubesheet, a change in the P-Number of tubesheet material for tube plugging

(d) Supplementary Essential Variables

(1) There are no Supplementary Essential Variables.

(e) Procedure Qualification Specimens

(1) Test Assembly

(-a) The procedure qualification test shall be performed using a mockup replicating the production weld position, tube hole pattern, and other essential variables listed in this subparagraph.

(-b) The test assembly tubesheet thickness shall be as thick as the production tubesheet, except that it need not be more than 1 in. (25 mm) greater than the length of the explosion plug.

(-c) When the explosive charge is to be placed less than one tube diameter from cladding or a tube-to-tubesheet weld, the qualification test assembly shall include cladding or tube-to-tubesheet welds, as applicable.

(-d) The minimum of ten (10) explosion welds shall be required for procedure qualification.

(2) Examination of Test Assembly

(-a) Explosion welds between plugs and cladding or tube-to-tubesheet welds, which are performed as required in (1)(-c), shall be examined by the liquid penetrant examination method in accordance with Section V, Article 6 and meet the acceptance criteria of QW-195.2.

(-b) Each plug weld and tube-to-tubesheet weld (when applicable) shall be sectioned longitudinally to reveal two cross-sectional faces, 180-deg apart. After polishing and etching the faces, each explosion weld joint area shall be metallographically examined at 10×

or greater magnification for the length of the explosion interface. The interface shall be considered acceptable if there is a minimum of five times the nominal tube wall thickness of continuous weld between the plug and tube or tubesheet on each cross-sectioned face. Each tube-to-tubesheet weld examination (if applicable) shall be considered acceptable if it is free from cracks as determined visually using 10× magnification.

(-c) Ligament distortion caused by explosion welding is unacceptable when the resulting adjacent tube I.D. is less than the outside diameter of the tube plug.

(-d) The procedure is qualified when all ten (10) of the required explosion welded tube plugs meet the requirements of (-a) through (-c) above.

3 WELDING OPERATOR PERFORMANCE QUALIFICATION

Tube plugging by explosion welding shall be performed by welding operators whose performance has been qualified as follows:

(a) *Required Tests.* The welding operator shall be qualified for explosion plug welding after successfully preparing a mockup consisting of a minimum of five explosion plug welds following a qualified explosion plug Welding Procedure Specification that meet the test acceptance criteria in [para. 2](#).

(b) *Examination of Test Assembly.* The five plugs shall be examined in accordance with the requirements of QW-193.2 and shall meet the given applicable acceptance standards.

(c) *Renewal of Qualification.* Renewal of qualification shall be performed in accordance with QW-193.2 and QW-322.

4 REPORT

This Case number shall be recorded on the welding procedure specification, procedure qualification record, and welding operator performance qualification.

Case 3003

Qualification of Partial and Full Penetration Corner Joints Using Laser Beam Welding

Section IV; Section IX

Approval Date: July 15, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For partial and full penetration corner joints made using laser beam welding (LBW), what alternative testing may be used in lieu of the mechanical testing required in QW-215.2 when qualifying a WPS to Section IX?

Reply: It is the opinion of the Committee that partial and full penetration corner joints may be welded following WPSs qualified in accordance with the following in lieu of the mechanical testing in QW-215.2:

(a) The metals shall be limited to P-No. 7 grades: UNS S44400, UNS S43035, and UNS S43932 and to those assigned to P-No. 8, P-No. 45, and P-No. 10H, including combinations of these metals

(b) For full-penetration corner joint welds, the base metal thickness shall not exceed 0.118 in. (3 mm).

(c) The properties of the welds shall be demonstrated by a burst test in accordance with HG-500 in order to verify the mechanical strength of the corner joint

under consideration. The test assembly and joint geometry shall duplicate that to be used in production. The test shall be acceptable when failure of the assembly occurs at or above the required bursting test pressure.

(d) Four cross-sections from a test assembly identical to that which was burst tested shall be removed, polished, and etched with a suitable etchant (see QW-470) to reveal the weld and heat-affected zone. If production welds will contain a lap-over, the test coupon shall include a lap-over, and one of the cross-sections shall be taken from that location. The weld and heat-affected zones of each cross-section shall exhibit complete fusion and be free of cracks when visually examined at 10× magnification.

(e) For partial penetration welds, the depth of penetration of each cross-section shall be measured to within 0.005 in. (0.13 mm), and the depth of penetration shall meet the specified production requirements.

(f) The PQR shall be prepared showing the configuration of the parts, a photomicrograph of at least one weld cross-section, the dimensions of the members at the joint, the measured and required weld size, reference to the bursting test report and the essential variables.

(g) This Case number shall be recorded on the WPS and on the Manufacturer's Data Report.

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Case 3004

Corner Weld With Partial Penetration for Construction of Stainless Steel Hot Water Heating Boiler

Section IV

Approval Date: July 15, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to perform partial penetration corner welds without the pressure limitation specified in HW-701.3(a) in hot water heating boiler constructions?

Reply: It is the opinion of the Committee that it is permissible to perform partial penetration corner welds without the pressure limitation specified in HW-701.3(a) in hot water heating boiler constructions, provided the following requirements are met:

(a) Partial penetration corner welds are not permitted in furnaces.

(b) The permissible materials are limited to stainless steel listed in Table HF-301, and for austenitic stainless steels, only low carbon grades are allowed.

(c) Corner joint shall be as shown in Figure HW-701.3, illustration (c).

(d) The head or tubesheet is supported by tubes.

(e) The welded joint is wholly within the shell and forms no part thereof. The throat of the fillet weld shall be not less than 0.7 times the thickness of the thinner plate.

(f) This construction is limited to closed loop water heating circuit.

(g) All other requirements of Section IV shall be met

(h) This Case number shall be shown on Manufacturer's Data Report.

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Case 3006

Solution Annealed Ni-44Cr-1Mo (UNS N06044) for Plate-Sheet-Strip, Seamless and Welded Fittings, Seamless Pipe and Tube, Forgings, Welded Pipe, Welded Tube and Rod

Section VIII, Division 1

Approval Date: September 3, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May plate-sheet-strip, seamless and welded fittings, seamless pipe and tube, forgings, welded pipe, welded tube and rod with the chemical analysis shown in [Table 1](#), mechanical properties listed in [Table 2](#), and otherwise conforming to the specifications listed in [Table 3](#) be used in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that plate-sheet-strip, seamless and welded fittings, seamless pipe and tube, forgings, welded pipe, welded tube and rod with the chemical analysis shown in [Table 1](#), mechanical properties listed in [Table 2](#), and otherwise conforming to the specifications listed in [Table 3](#) may be used in Section VIII, Division 1 construction, provided the following additional requirements are met:

(a) The material shall be solution annealed within the temperature range of 2,100°F to 2,230°F (1 150°C to 1 220°C).

(b) The yield strength and tensile strength values for use in design shall be as shown in [Table 4](#) ([Table 4M](#)).

(c) The maximum allowable stress values for the material shall be those given in [Table 5](#) ([Table 5M](#)).

(d) The maximum design temperature shall be 800°F (427°C).

(e) The rules for nickel, cobalt, and high nickel alloys in Subsection C, Part UNF shall apply.

(f) The following physical properties shall apply:

(1) density: 0.29 lb/in.³ (7 970 kg/m³)

(2) linear expansion as is listed in [Table 6](#) ([Table 6M](#))

(3) specific heat as listed in [Table 7](#) ([Table 7M](#))

(4) thermal conductivity as listed in [Table 8](#) ([Table 8M](#))

(5) elastic modulus and Poisson's Ratio as listed in [Table 9](#) ([Table 9M](#))

(6) thermal diffusivity as listed in [Table 10](#) ([Table 10M](#))

(g) Separate weld procedure and performance qualifications conducted in accordance with Section IX shall be required for this material. Welding shall be limited to the GTAW and GMAW processes.

(h) For external pressure design, Section II, Part D, Figure NFN-15 and Table NFN-15 shall apply.

(i) This Case number shall be shown in the documentation and marking of the material and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition Limits, %
Carbon, max.	0.02
Manganese	0.07–0.30
Phosphorous, max.	0.020
Sulfur, max.	0.020
Silicon, max.	0.20
Aluminum, max.	0.30
Iron, max.	0.3
Titanium	0.10–0.30
Chromium	43.5–45.3
Molybdenum	0.80–1.20
Nickel	Bal.

Table 2
Mechanical Properties Corresponding to Product Forms

Property	Requirement
Plate-Sheet-Strip, Welded and Seamless Fittings, Seamless Pipe and Tube and Forgings	
Tensile strength, min., MPa (ksi)	690 (100)
Yield strength, min., MPa (ksi)	310 (45)
Elongation in 2 in., min., %	30
Welded Pipe and Welded Tube	
Tensile strength, min., MPa (ksi)	620 (90)
Yield strength, min., MPa (ksi)	310 (45)
Elongation in 2 in., min., %	20
Rod	
Tensile strength, min., MPa (ksi)	690 (100)
Yield strength, min., MPa (ksi)	280 (41)
Elongation in 2 in., min., %	30

Table 3
Specifications

Product	Specification
Forgings	SB-564
Plate, sheet, and strip	SB-575
Rod	SB-574
Seamless and welded fittings	SB-366
Seamless pipe and tube	SB-622
Welded pipe	SB-619
Welded tube	SB-626

Table 4
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Plate-Sheet-Strip, Seamless and Welded Fittings, Seamless Pipe and Tube and Forgings		Welded Pipe and Welded Tube		Rod	
	Yield Strength, S_y , ksi [Note (1)]	Tensile Strength, S_u , ksi [Note (2)]	Yield Strength, S_y , ksi [Note (1)]	Tensile Strength, S_u , ksi [Note (2)]	Yield Strength, S_y , ksi [Note (1)]	Tensile Strength, S_u , ksi [Note (2)]
100	45.0	100	45.0	89.9	40.6	100
200	39.8	100	39.8	89.9	36.0	100
300	37.2	97.0	37.2	87.2	33.6	97.0
400	35.6	94.2	35.6	84.7	32.1	94.2
500	34.7	92.5	34.7	83.1	31.3	92.5
600	34.3	91.3	34.3	82.0	31.0	91.3
650	34.2	90.7	34.2	81.5	30.9	90.7
700	34.2	90.2	34.2	81.0	30.9	90.2
750	34.2	89.5	34.2	80.4	30.9	89.5
800	34.2	88.7	34.2	79.7	30.9	88.7

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, General Note (b) applies to these values.
(2) Section II, Part D, Subpart 1, Table U, General Note (b) applies to these values.

Table 4M
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °C	Plate-Sheet-Strip, Seamless and Welded Fittings, Seamless Pipe and Tube and Forgings		Welded Pipe and Welded Tube		Rod	
	Yield Strength, S_y , MPa [Note (1)]	Tensile Strength, S_u , MPa [Note (2)]	Yield Strength, S_y , MPa [Note (1)]	Tensile Strength, S_u , MPa [Note (2)]	Yield Strength, S_y , MPa [Note (1)]	Tensile Strength, S_u , MPa [Note (2)]
40	310	690	310	620	280	690
65	287	690	287	620	259	690
100	272	690	272	620	246	690
125	264	681	264	612	238	681
150	257	669	257	601	232	669
175	251	659	251	592	226	659
200	246	651	246	585	222	651
225	242	645	242	579	219	645
250	240	639	240	574	217	639
275	238	635	238	571	215	635
300	237	631	237	567	214	631
325	236	628	236	564	213	628
350	236	625	236	561	213	625
375	236	621	236	558	213	621
400	236	617	236	555	213	617
425	236	612	236	550	213	612
450 [Note (3)]	236	606	236	545	213	606

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, General Note (b) applies to these values.
(2) Section II, Part D, Subpart 1, Table U, General Note (b) applies to these values.
(3) The values at 450°C are for interpolation only; the maximum design temperature shall be 427°C.

**Table 5
Maximum Allowable Stress Values**

For Metal Temperature Not Exceeding, °F	Allowable Stress, ksi					
	Plate-Sheet-Strip, Seamless and Welded Fittings, Seamless Pipe and Tube and Forgings		Welded Pipe and Welded Tube		Rod	
	High	Low	High	Low	High	Low
100	28.6	28.6	21.8	21.8	27.1	27.1
200	28.6 [Note (1)]	26.6	21.8	21.8	27.1 [Note (1)]	24.0
300	27.7 [Note (1)]	24.8	21.2 [Note (1)]	21.1	27.1 [Note (1)]	22.4
400	26.9 [Note (1)]	23.7	20.6 [Note (1)]	20.2	26.9 [Note (1)]	21.4
500	26.4 [Note (1)]	23.1	20.2 [Note (1)]	19.6	26.4 [Note (1)]	20.9
600	26.1 [Note (1)]	22.9	19.9 [Note (1)]	19.4	26.1 [Note (1)]	20.6
650	25.9 [Note (1)]	22.8	19.8 [Note (1)]	19.4	25.9 [Note (1)]	20.6
700	25.8 [Note (1)]	22.8	19.7 [Note (1)]	19.4	25.8 [Note (1)]	20.6
750	25.6 [Note (1)]	22.8	19.5 [Note (1)]	19.4	25.6 [Note (1)]	20.6
800	25.4 [Note (1)]	22.8	19.4	19.4	25.4 [Note (1)]	20.6

NOTE: (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 5M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Allowable Stress, MPa					
	Plate-Sheet-Strip, Seamless and Welded Fittings, Seamless Pipe and Tube and Forgings		Welded Pipe and Welded Tube		Rod	
	High	Low	High	Low	High	Low
40	197	197	151	151	187	187
65	197 [Note (1)]	191	151	151	187 [Note (1)]	173
100	197 [Note (1)]	181	151	151	187 [Note (1)]	164
125	194 [Note (1)]	176	149	149	187 [Note (1)]	159
150	191 [Note (1)]	171	146 [Note (1)]	145	187 [Note (1)]	154
175	188 [Note (1)]	167	144 [Note (1)]	142	187 [Note (1)]	151
200	186 [Note (1)]	164	142 [Note (1)]	139	186 [Note (1)]	148
225	184 [Note (1)]	162	141 [Note (1)]	137	184 [Note (1)]	146
250	183 [Note (1)]	160	140 [Note (1)]	136	183 [Note (1)]	144
275	181 [Note (1)]	159	139 [Note (1)]	135	181 [Note (1)]	143
300	180 [Note (1)]	158	138 [Note (1)]	134	180 [Note (1)]	143
325	179 [Note (1)]	157	137 [Note (1)]	134	179 [Note (1)]	142
350	178 [Note (1)]	157	136 [Note (1)]	134	178 [Note (1)]	142
375	177 [Note (1)]	157	136 [Note (1)]	134	177 [Note (1)]	142
400	176 [Note (1)]	157	135 [Note (1)]	134	176 [Note (1)]	142
425	175 [Note (1)]	157	134	134	175 [Note (1)]	142
450 [Note (2)]	173 [Note (1)]	157	134 [Note (1)]	132	173 [Note (1)]	142

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) The value at 450°C is for interpolation only; the maximum use temperature is 427°C.

Table 6
Thermal Expansion, Mean Coefficient

Temperature, °F	Thermal Expansion, Mean Coefficient, $\times 10^{-6}$ in./in./°F
68	7.0
200	7.15
300	7.28
400	7.41
500	7.53
600	7.65
700	7.77
800	7.89

GENERAL NOTE: From 68°F to indicated temperature.

Table 6M
Thermal Expansion, Mean Coefficient

Temperature, °C	Thermal Expansion, Mean Coefficient, $\times 10^{-6}$ mm/mm/°C
100	12.9
200	13.3
300	13.7
400	14.1
500	14.4

GENERAL NOTE: From 20°C to indicated temperature.

**Table 7
Specific Heat**

Temperature, °F	Specific Heat, Btu lb ⁻¹ °F ⁻¹
68	0.098
200	0.111
300	0.116
400	0.119
500	0.122
600	0.123
700	0.126
800	0.128

**Table 7M
Specific Heat**

Temperature, °C	Specific Heat, J·g ⁻¹ K ⁻¹
20	0.441
100	0.471
200	0.499
300	0.515
400	0.531
500	0.544

**Table 8
Thermal Conductivity**

Temperature, °F	Thermal Conductivity, Btu/hr ft °F
68	6.01
200	6.93
300	7.81
400	8.23
500	8.93
600	9.66
700	10.2
800	10.7

**Table 8M
Thermal Conductivity**

Temperature, °C	Thermal Conductivity, W/(m °C)
20	10.4
100	12.1
200	14.3
300	16.3
400	18.2
500	20.0

**Table 9
Elastic Modulus and Poisson's Ratio**

Temperature, °F	Elastic Modulus, × 10 ⁶ psi	Poisson's Ratio
68	27.5	0.38
200	27.4	0.38
300	27.0	0.38
500	26.4	0.38
700	25.7	0.38
900	25.3	0.38

**Table 9M
Elastic Modulus and Poisson's Ratio**

Temperature, °C	Elastic Modulus, × 10 ⁶ MPa	Poisson's Ratio
20	190	0.38
100	189	0.38
200	186	0.38
300	182	0.38
400	177	0.38
500	174	0.38

**Table 10
Thermal Diffusivity**

Temperature, °F	Thermal Diffusivity, ft ² /s × 10 ⁻⁶
68	3.18
100	3.21
200	3.42
300	3.69
400	3.90
500	4.01
600	4.31
700	4.50
800	4.68
900	4.89

**Table 10M
Thermal Diffusivity**

Temperature, °C	Thermal Diffusivity, m ² /s × 10 ⁻⁶
20	2.95
100	3.23
200	3.60
300	3.96
400	4.30
500	4.61

Case 3007 9Cr-2Si-1Cu Material

Section VIII, Division 1

Approval Date: September 8, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 9Cr-2Si-1Cu seamless tubes and pipes meeting the chemical composition and mechanical property requirements shown in Tables 1 and 2, and otherwise conforming to one of the specifications given in Table 3, be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that that the material described in the Inquiry may be used in Section VIII, Division 1 construction provided the following additional requirements are met:

(a)) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UCS for carbon and alloy steels.

(b)) For the purpose of impact test requirements, this material shall be considered as a Curve B material in Figure UCS-66.

(c) External pressure design is prohibited.

(d) The maximum allowable stress values for the material shall be those given in Table 4 (Table 4M).

(e) Maximum design temperature of the material shall not exceed be 1,300°F (704°C).

(f) The material shall be austenitized within the temperature range 1,670°F to 1,740°F (910°C to 950°C) followed by air cooling and tempered within the range 1,350°F to 1,440°F (730°C to 770°C).

(g) The material in the final tempered condition shall not exceed a Brinell Hardness Number of 276 HBW (290HV10).

(h) Separate welding procedure qualifications shall be conducted for the material in accordance with Section IX.

(i) For welder performance qualifications, this material shall be considered as being P-No. 5B, Group 1.

(j) Postweld heat treatment shall be performed between 1,310°F to 1,400°F (710°C to 770°C). The time requirement shall be those given for P-No. 5B, Group 1 materials in Table UCS-56-4.

(k) Welding shall be limited to GTAW.

(l) Cold-forming rules in UG-79 and UCS-79 shall apply, except austenitizing and tempering shall be as in (f). Specifically, for cold formed flares, swages, and upsets in tubing

or pipe, regardless of the dimension and the amount of cold work, the material shall be re-austenitized and tempered in accordance with (f).

(m) The tensile strength, S_u , and yield strength, S_y , values are listed in Tables 5 and 6 (Tables 5M and 6M), respectively.

(n) For physical properties, see Table 7 (Table 7M).

(o) This Case number shall be shown on the documentation and marking of the material and on the Manufacturer's Data Report.

**Table 1
Chemical Requirements**

Element	Composition Limits, %
Carbon	0.08-0.12
Manganese	0.5-0.7
Phosphorous, max.	0.03
Sulfur, max.	0.02
Silicon	1.6-2.2
Chromium	8.0-9.5
Molybdenum	0.8-1.1
Nickel	0.8-1.4
Nitrogen	0.02-0.05
Aluminum, max.	0.04
Copper	0.8-1.4

Table 2
Mechanical Properties Requirements

Mechanical Property	Requirement
Tensile strength, min., ksi (MPa)	109 (750)
Yield strength, min., ksi (MPa)	84 (580)
Elongation in 2 in. (50.8 mm), min., % [Note (1)]	19

NOTE: (1) For longitudinal strip tests, a deduction from the basic values of 1.00% for each $\frac{1}{32}$ in. (0.8 mm) decrease in wall thickness below $\frac{5}{16}$ in. (7.8 mm) shall be made. The following table gives the computed values.

Wall Thickness, in. (mm)	Elongation in 2 in. (50.8 mm), Min., %
0.312 (7.8)	19
0.281 (7.1)	18
0.250 (6.4)	17
0.219 (5.3)	16
0.188 (4.8)	15
0.156 (4.0)	14
0.125 (3.2)	13
0.094 (2.4)	14
0.062 (1.5)	12
0.062 to 0.035 (0.9 to 1.5), excl.	10.9
0.035 to 0.022 (0.6 to 0.9), excl.	10.6
0.022 to 0.015 (0.4 to 0.6), incl.	10.3

GENERAL NOTE: The above table gives the computed minimum elongation values for each $\frac{1}{32}$ in. (0.8 mm) decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value shall be determined by the following equation:

(U.S. Customary Units)

$$E = 32t + 10.0$$

(SI Units)

$$E = 1.25t + 10.0$$

where

- E = elongation in 2 in. (50.8 mm), %
 t = actual thickness of specimen, in. (mm)

Table 3
Product Specifications

Product	Specification
Pipe	SA-335/SA-335M
Tube	SA-213/SA-213M, SA-335/SA-335M

Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
Up to 100	31.1
200	31.1
300	30.6
400	30.3
500	30.2
600	30.0
650	29.6
700	29.1
750	28.3
800	27.3
850	23.5 [Note (1)]
900	16.7 [Note (1)]
950	11.6 [Note (1)]
1,000	7.9 [Note (1)]
1,050	5.3 [Note (1)]
1,100	3.5 [Note (1)]
1,150	2.4 [Note (1)], [Note (2)]
1,200	1.6 [Note (1)], [Note (2)]
1,250	1.1 [Note (1)], [Note (2)]
1,300	0.8 [Note (1)], [Note (2)]

NOTES:

- (1) These values are obtained from time-dependent properties.
 (2) These values are obtained from two heats.

Table 4M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
Up to 40	214
100	214
200	209
300	207
400	195
425	188
450	170 [Note (1)]
475	126 [Note (1)]
500	91.3 [Note (1)]
525	65.2 [Note (1)]
550	46.0 [Note (1)]
575	31.9 [Note (1)]
600	22.1 [Note (1)]
625	15.4 [Note (1)], [Note (2)]
650	10.9 [Note (1)], [Note (2)]
675	7.8 [Note (1)], [Note (2)]
700	5.7 [Note (1)], [Note (2)]
725	4.2 [Note (1)], [Note (2)], [Note (3)]

NOTES:

- (1) These values are obtained from time-dependent properties.
 (2) These values are obtained from two heats.
 (3) The maximum use temperature shall be 704°C. Datum for 725°C temperature is provided for interpolation purposes.

Table 5
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °F	Tensile Strength Values, S_u , ksi [Note (1)]
Up to 100	108.8
200	100.4
300	97.3
400	96.3
500	96.1
600	95.3
650	94.3
700	92.5
750	90.1
800	86.7
850	82.5
900	77.3
950	71.2
1,000	64.3
1,050	56.7
1,100	48.6
1,150	40.4
1,200	32.5
1,250	25.2
1,300	19.1

NOTE: (1) The tabulated values of tensile strength are those which the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 5M
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °C	Tensile Strength Values, S_u , MPa [Note (1)]
Up to 40	750
65	710
100	688
150	671
200	665
250	663
300	660
325	655
350	648
375	636
400	620
425	600
450	574
475	543
500	507
525	466
550	420
575	372
600	322
625	271
650	222
675	176
700	138
725	109 [Note (2)]

NOTES:

- (1) The tabulated values of tensile strength are those which the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the values of tensile strength tend toward an average or expected value which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. The tensile strength values do not correspond exactly to “average” as this term is applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for tensile strengths of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated tensile strength values for ASME Code acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The maximum use temperature shall be 704°C. Datum for 725°C temperature is provided for interpolation purposes.

Table 6
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °F	Yield Strength Values, S_y , ksi [Note (1)]
Up to 100	84.1
200	77.9
300	72.7
400	69.0
500	67.2
600	66.6
650	66.4
700	65.9
750	65.0
800	63.6
850	61.4
900	58.3
950	54.3
1,000	49.4
1,050	43.6
1,100	37.0
1,150	30.0
1,200	22.8
1,250	15.9
1,300	9.9

NOTE: (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.

Table 6M
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °C	Yield Strength Values, S_y , MPa [Note (1)]
Up to 40	580
65	557
100	533
150	500
200	477
250	465
300	460
325	459
350	457
375	454
400	448
425	439
450	426
475	408
500	385
525	357
550	324
575	286
600	244
625	200
650	155
675	112
700	74.5
725	45.2 [Note (2)]

NOTES:

- (1) The tabulated values of yield strength are those that the Committee believes are suitable for use in design calculations. At temperatures above room temperature, the yield strength values correspond to the yield strength trend curve adjusted to the minimum specified room temperature yield strength. The yield strength values do not correspond exactly to “minimum” or “average,” as those terms are applied to a statistical treatment of a homogeneous set of data. Neither the ASME Material Specifications nor the rules of Section I require elevated temperature testing for yield strength of production material for use in Code components. It is not intended that results of such tests, if performed, be compared with these tabulated yield strength values for ASME acceptance/rejection purposes for materials. If some elevated temperature test results on production material appear lower than the tabulated values by a large amount (more than the typical variability of material and suggesting the possibility of some error), further investigation by retest or other means should be considered.
- (2) The maximum use temperature shall be 704°C. Datum for 725°C temperature is provided for interpolation purposes.

Table 7
Physical Properties

Temperature, °F	Density, ρ , lb/in. ³	Modulus of Elasticity, E , ksi	Shear Modulus, G , ksi	Thermal Conductivity, λ , Btu/(ft-hr-°F)	Mean CTE, α , 10 ⁻⁶ in./in./°F [Note (1)]	True Specific Heat Capacity, C_p , Btu/lb °F	Poisson's Ratio, ν	Thermal Diffusivity, α , ft ² /hr
68	0.277	30,917	12,028	10.2	...	0.091	0.29	0.193
100	0.277	30,719	11,951	10.4	6.9	0.096	0.29	0.194
200	0.276	30,128	11,715	11.0	6.9	0.111	0.29	0.196
300	0.276	29,562	11,484	11.5	6.9	0.121	0.29	0.198
400	0.275	28,998	11,248	12.0	6.9	0.128	0.29	0.199
500	0.275	28,414	11,000	12.3	7.0	0.134	0.29	0.198
600	0.274	27,787	10,734	12.6	7.0	0.138	0.29	0.196
700	0.273	27,093	10,440	12.8	7.0	0.143	0.30	0.193
800	0.273	26,311	10,111	13.0	7.1	0.150	0.30	0.187
900	0.272	25,417	9,741	13.2	7.1	0.160	0.30	0.180
1,000	0.272	24,389	9,320	13.5	7.1	0.173	0.31	0.171
1,100	0.271	23,204	8,841	13.7	7.1	0.191	0.31	0.159
1,200	0.271	21,840	8,297	14.0	7.2	0.215	0.32	0.145
1,300	0.270	20,272	7,680	14.4	7.2	0.247	0.32	0.128

NOTE: (1) Mean CTE values are those from 68°F to indicated temperature.

Table 7M
Physical Properties

Temperature, °C	Density, ρ , 10 ³ kg/m ³	Modulus of Elasticity, E , GPa	Shear Modulus, G , GPa	Thermal Conductivity, λ , W/m K	Mean CTE, α , 10 ⁻⁶ /K [Note (1)]	True Specific Heat Capacity, C_p , J/kg K	Poisson's Ratio, ν	Thermal Diffusivity, α , 10 ⁻⁶ m ² /s
20	7.67	212	83	18.0	...	379	0.29	5.0
50	7.66	211	82	18.1	12.4	424	0.29	5.0
100	7.65	208	81	19.0	12.5	474	0.29	5.1
150	7.63	204	79	19.8	12.5	504	0.29	5.1
200	7.62	201	78	20.5	12.5	525	0.29	5.1
250	7.60	197	76	21.1	12.5	547	0.29	5.1
300	7.59	193	75	21.6	12.5	570	0.29	5.1
350	7.58	188	73	22.1	12.6	594	0.30	5.0
400	7.56	183	71	22.7	12.7	619	0.30	4.9
450	7.55	178	69	23.1	12.8	660	0.30	4.8
500	7.53	173	66	23.3	12.8	707	0.31	4.6
550	7.52	167	64	23.5	12.8	735	0.31	4.4
600	7.50	160	61	24.0	12.8	775	0.32	4.1
650	7.49	151	57	24.3	12.9	889	0.32	3.7
700	7.47	139	53	24.5	12.9	1045	0.32	3.4

NOTE: (1) Mean CTE values are those from 20°C to indicated temperature.

Case 3008

Extension of Cementing Technicians Qualification Continuity, Part UIG

Section VIII, Division 1

Approval Date: September 15, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an organization extend the qualification continuity of cementing technicians?

Reply: It is the opinion of the Committee that the qualification continuity of cementing personnel technicians who have experienced an employment interruption due to the COVID-19 outbreak may be extended an addi-

tional six months beyond that allowed by UIG-80(d), provided the following requirements are met:

(a) The qualification was valid at the time of the employment interruption.

(b) The qualification was scheduled to expire during the employment interruption.

The latest date the cementing technician uses the process within the extended period will be the new date for continuity purposes. UIG-80(d) shall still apply for the cementing technician whose continuity has been extended.

This Case number shall be shown in the cementing technician's continuity record.

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Case 3010 Combination Boilers

Section IV

Approval Date: October 6, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a hot water heating boiler or a hot water supply boiler with an integrated coil responsible for potable water heating and working under a separate MAWP value be certified with the H designator, and marked with two MAWP values on the nameplate?

Reply: It is the opinion of the Committee that a hot water heating boiler or a hot water supply boiler with an integrated coil responsible for potable water heating and working under a separate MAWP value may be certified with the H designator, and marked with two MAWPs on the nameplate, provided the following requirements are met:

(a) The scope of marking applied on the combination boiler or its nameplate shall be in accordance with [Figure 1](#).

(b) Each water connection shall be permanently and legibly marked with “Heating Water” on the heating water connections and “Potable Water” on the potable water connections. The marking shall be in characters not less than 5/32 in. (4 mm). The method and control of the applied marking, and its traceability shall be as described in the Manufacturer’s Quality Control Manual.

(c) The “Remarks” section of the Manufacturer’s Data Report shall include the MAWP values specified on the combination boiler or its nameplate.

(d) The coil responsible for potable water heating shall be made of corrosion resistant materials permitted by Section IV and comply with both H and HLW requirements.

(e) The water temperature shall not exceed 210°F (99°C) for both pressure sides.


(f) Both pressure sides shall be subjected to a hydrostatic test in accordance with HG-510. Each pressure side shall be tested separately with atmospheric pressure on the adjacent side.

(g) Each pressure side shall have its own safety relief valve. The heating water side shall be provided with a safety relief valve in accordance with HG-400.2. The potable water side shall be provided with a safety relief valve in accordance with HLW-800.1 with an exception that the required relieving capacity in Btu/hr shall be based on the maximum heat absorption of the coil established by the Manufacturer.

(h) All other applicable requirements of Section IV shall be met.

(i) This Case number shall be shown on the Manufacturer’s Data Report.

**Figure 1
Scope of Marking**

	Certified by	

	(Name of Manufacturer)	
	Heating Water Side	Potable Water Side
MAWP	_____	_____
Maximum water temp.	_____	_____
Min. relief valve capacity	_____	_____
Max. allowable input	_____	
Heating surface [Notes (1), (2)]	_____ boiler	
Heating surface [Notes (1), (2)]	_____ waterwall	
Manufacturer’s serial no.	_____	
Year built [Note (3)]	_____	

NOTES:

- (1) This applies to heating water side only.
- (2) List each type of heating surface separately. May be omitted if type heating surface is not present. May be also replaced with one single value representing total heating surface (see HG-403).
- (3) This may be omitted when year built is incorporated into the serial number as a prefix (see HG-530.1).

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Case 3012

Use of SB-584 UNS C87500 Castings

Section VIII, Division 1

Approval Date: December 9, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS C87500 castings conforming to SB-584 be used for Section VIII, Division 1 pressure vessels?

Reply: It is the opinion of the Committee that UNS C87500 castings conforming to SB-584 may be used for Section VIII, Division 1 pressure vessels, provided the following requirements are met:

(a) The maximum allowable stress values shall be as given in [Tables 1](#) and [1M](#). The maximum design temperature is 375°F (191°C).

(b) The yield strength and tensile strength shall be as given in [Tables 2](#) and [2M](#).

(c) Welding and brazing are prohibited.

(d) The material shall not be subject to external pressure.

(e) The rules of Section VIII, Division 1, Subsection C, Part UNF for copper alloys shall apply.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Temperatures Not Exceeding, °F	Maximum Allowable Stress, ksi
100	16.0
150	14.8
200	14.8
250	14.7
300	14.4
350	14.4
400 [Note (1)]	14.4

NOTE: (1) Value is provided for interpolation. Maximum use temperature is 375°F.

Table 1M
Maximum Allowable Stress Values

For Temperatures Not Exceeding, °C	Maximum Allowable Stress, MPa
40	110
65	102
100	102
125	101
150	100
175	100
200 [Note (1)]	100

NOTE: (1) Value is provided for interpolation. Maximum use temperature is 191°C.

Table 2
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
100	24.0	60.0
150	22.2	...
200	22.2	60.0
250	22.0	...
300	21.7	60.0
350	21.7	...
400	21.7	60.0

NOTES:

- (1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).
- (2) See Section II, Part D, Subpart 1, Table U, General Note (b).

Table 2M
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
40	165	414
65	153	414
100	153	414
125	152	414
150	149	414
175	149	414
200	149	414

NOTES:

- (1) See Section II, Part D, Subpart 1, Table Y-1, General Note (b).
- (2) See Section II, Part D, Subpart 1, Table U, General Note (b).

Case 3014

Use of SA-268/SA-268M, UNS S43932 Seamless and Welded Tubes

Section I

Approval Date: December 10, 2020

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S43932 ferritic stainless steel in form of SA-268/SA-268M seamless and welded tube be used in Section I construction?

Reply: It is the opinion of the Committee that UNS S43932 ferritic stainless steel in form of SA-268/SA-268M seamless and welded tube may be used in Section I construction, provided the following requirements are met:

(a) The maximum allowable stress values and Notes shall be those for 18Cr-Ti, seamless or welded tube, as applicable, SA-268/SA-268M UNS S43035 material in Section II, Part D, Table 1A.

(b) The maximum design temperature shall be 600°F (316°C).

(c) For external pressure, Section II, Part D, Figure CS-2 shall be used.

(d) For the purposes of welding procedure and performance qualification, the material shall be considered as P-No. 7, Group No. 2.

(e) Postweld heat treatment is not required if the thickness at the welded joint does not exceed $\frac{3}{8}$ in. (10 mm).

(f) All other applicable requirements of Section I shall be met.

(g) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3016

Use of Additively Manufactured Base Metal for Welding Procedure Qualifications

Section IX

Approval Date: January 28, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what circumstances may plates manufactured by wire additive processes be considered as ASTM B26/ASME SB-26, Temper T6, UNS A03560 for procedure qualifications?

Reply: It is the opinion of the Committee that plates manufactured using SFA-5.10, ER4008 or ER4010 filler metal followed by machining and tempering to Temper T6 may be considered the same P-Number and UNS number as ASTM B26/ASME SB-26, Temper T6, UNS A03560 for the purpose of welding procedure qualification, provided that the plates meet the chemical composition and mechanical property requirements of ASTM B26, Temper T6, UNS A03560.

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Case 3017

Increasing Maximum Design Pressure Limitation for Class I Filament Wound Pressure Vessels From 1,500 psi to 2,000 psi

Section X

Approval Date: February 23, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to increase the maximum internal design pressure limitation of Section X, Class I filament-wound vessels from 1,500 psi to 2,000 psi?

Reply: It is the opinion of the Committee that Section X, Class I filament-wound vessels may be fabricated with maximum internal design pressures up to 2,000 psi, provided the following requirements are met:

(a) The pressure vessels shall totally conform to the all requirements for Section X, Class I pressure vessel requirements including the following:

- (1) Part RG, General Requirements: with the exception of the 1,500-psi limitation noted in RG-111
- (2) Part RM, Material Requirements
- (3) Part RD, Design Requirements: with the exception of the 1,500-psi limitation noted in RD-111
- (4) Part RF, Fabrication Requirements
- (5) Part RQ, Qualification Requirements
- (6) Part RR, Pressure Relief Devices
- (7) Part RT, Rules Governing Testing: with the exception of the 1,500-psi limitation noted in RT-412.2
- (8) Part RI, Inspection Requirements
- (9) Part RS, Marking, Stamping, and Reports
- (10) Mandatory Appendices 1 through 7

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Case 3018

Diffusion Welding of Microchannel Heat Exchangers

Section VIII, Division 1

Approval Date: March 16, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may diffusion welding be used for the construction of microchannel heat exchangers in accordance with Section VIII, Division 1?

Reply: It is the opinion of the Committee that diffusion welding may be used for the construction of microchannel heat exchangers in accordance with Section VIII, Division 1, provided the following requirements are met:

(a) Welding shall be performed in accordance with UW-26.

(b) *Design*

(1) A joint efficiency of 0.7 shall be used for the diffusion welded interface.

(2) For a regular pattern of rectangular microchannels, design calculations shall be in accordance with one of the following:

(-a) Mandatory Appendix 13, 13-9

(-b) an analytical procedure per Section VIII, Division 2, Part 5, 5.2.3

(3) For patterns other than described in (2), refer to U-2(g) for requirements.

(c) Production diffusion welded joints shall be examined in the following sequence:

(1) Ultrasonic examination of areas within $T/2$ of external attachment welds on the endplate shall be performed in accordance with UW-53(a), where T is the thickness of the attachment.

(2) Liquid penetrant examination shall be performed in accordance with Mandatory Appendix 8.

(-a) When machining is performed, the examination shall be performed after machining.

(-b) *Acceptance criteria:* No indications on or adjacent to the weld interface.

(3) Visual examination shall be performed in accordance with Section V, Article 9. For acceptance criteria, the diffusion weld shall be free from cracks and shall show no separation or porosity on or adjacent to the weld interface.

(4) Hydrostatic testing shall be applied in accordance with UG-99, or pneumatic testing may be applied in lieu of hydrostatic testing in accordance with UG-100.

(d) This Case number shall be referenced on the Manufacturer's Data Report.

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Case 3020

Qualification of Gas Metal Arc Additive Manufacturing (GMAAM) Procedures

Section IX

Approval Date: May 24, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What rules may be used to qualify gas metal arc additive manufacturing (GMAAM) procedures?

Reply: It is the opinion of the Committee that the rules for GMAAM procedure qualification may follow the rules for welding procedure qualification as given in Section IX with the following modifications:

(a) The welding process shall be limited to automatic gas metal arc welding (GMAW).

(b) [Table 1](#) specifies the welding variables.

(c) New variables shall be as shown as follows:

(1) For [QG-109.2](#), add the following definitions:

bracketed qualification: a procedure qualification that requires testing at combinations of high and low values of specific variables that then determines the allowable range for those variables in a qualified procedure.

gas metal arc additive manufacturing (GMAAM): the deposition of weld metal using the gas metal arc welding (GMAW) process to create a new component either separately or joined to an existing component.

integrated backing: base metal that is not removed from the weldment and is included in the final part.

(2) Insert as [QW-153.1\(x\)](#):

The minimum tensile properties specified by the referencing code or document.

(3) Insert as last paragraph for [QW-171.3](#):

When qualifying GMAAM procedures, the toughness specimens shall be removed as shown in [Figures 1](#) and [2](#).

(4) Insert as [QW-403.x](#):

A change in the number of weld beads per layer beyond the range qualified, as shown in [Table 2](#).

(5) Insert as [QW-406.x](#):

An increase of more than 100°F (55°C) in the interpass temperature of the high heat input/high interpass temperature bracketed qualification or a decrease of more than 100°F (55°C) in the interpass temperature of the low heat input/low interpass temperature bracketed qualification. This variable does not apply when a WPS is qualified with a PWHT above the upper transformation temperature.

(6) Insert as [QW-409.x](#):

A heat input below that qualified in the low heat input/low interpass temperature bracketed qualification or a heat input above that qualified in the high heat input/high interpass temperature bracketed qualification. Heat input shall be calculated using the formulae in [QW-409.1](#).

NOTE: The “x” in paragraph references are to be determined.

(d) When base metal is not integral, P-Number is a nonessential variable.

(e) [Table 2](#) defines the number and type of test specimens and the beads per layer, *B*, and layer widths, *W*, qualified.

(f) [Figures 1](#) and [2](#) define the number of specimens and the location of their removal from the qualification weld coupon.

(g) Welding operator performance qualification shall be in accordance with [QW-361.1](#).

(h) This Case number shall be recorded on the WPS, the PQR, and Manufacturer’s Data/Partial Data Report.

**Table 1
Variables**

Paragraph		Brief of Variables	Essential	Nonessential
QW-403, Base Metals	.5	Ø Group number	x	
	.9	<i>t</i> pass >1/2 in. (13 mm)	x	
	.x	<i>B</i> limits	x	
	.x	<i>W</i> limits	x	
QW-404, Filler Metals	.4	Ø F-Number	x	
	.5	Ø A-Number	x	
	.6	Ø Diameter		x
	.12	Ø Classification	x	
	.23	Ø Filler metal product form	x	
	.24	± or Ø Supplemental	x	
	.27	Ø Alloy elements	x	
	.30	Ø <i>t</i>	x	
	.33	Ø Classification		x
QW-405, Positions	.1	+ Position		x
	.2	Ø ↑↓ Vertical welding		x
QW-406, Preheat	.1	Decrease >100°F (>55°C)	x	
	.2	Ø Preheat maintenance		x
	.x	Increase >100°F (>55°C)	x	
QW-407, PWHT	.1	Ø PWHT	x	
	.2	Ø PWHT (T & T range)	x	
QW-408, Gas	.1	± Trail or Ø composition		x
	.2	Ø Single, mixture, or %	x	
	.3	Ø Flow rate		x
	.5	± or Ø Backing flow		x
	.9	- Backing or Ø composition	x	
	.10	- Trail or Ø composition	x	
QW-409, Electrical Characteristics	.x	Ø Heat input	x	
	.2	Ø Transfer mode	x	
	.4	Ø Current or polarity	x	
	.8	Ø I & E range		x
QW-410, Technique	.3	Ø Orifice, cup, or nozzle size		x
	.5	Ø Method cleaning		x
	.7	Ø Oscillation		x
	.8	Ø Tube-work distance		x
	.10	Ø Single to multiple electrodes	x	
	.15	Ø Electrode spacing	x	
	.26	± Peening		x

Legend:

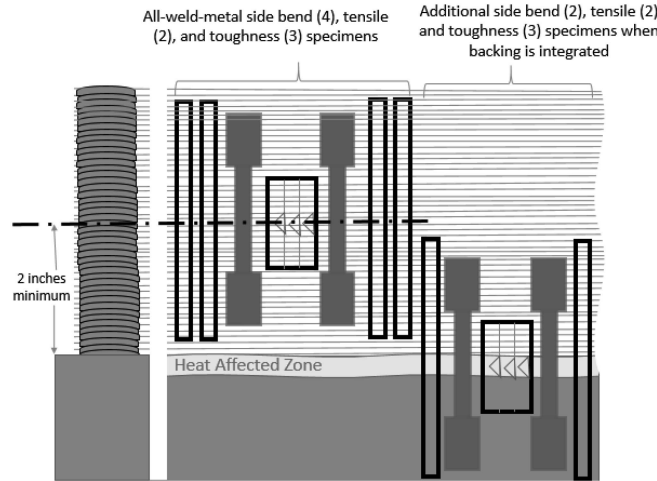
- + = Addition
- = Deletion
- > = Increase or greater than
- < = Decrease or less than
- ↑ = Uphill
- ↓ = Downhill
- Ø = Change

GENERAL NOTE: The "x" in paragraph references are to be determined.

Table 2
GMAAM Procedure Qualification Bead and Layer Width Limits and Test Specimens

Number of Weld Beads per Layer of Test Coupon Welded, <i>B</i>	Layer Width of Test Coupon Welded, <i>W</i>	Number of Weld Beads per Layer Qualified	Maximum Layer Width Qualified	Required Tests per Figures 1 and 2					
				Without Integrated Backing			Backing P-No. Qualified		
				Tension, QW-150	Charpy V-Notch Toughness, QW-170	Side Bend, QW-160	Tension, QW-150	Charpy V-Notch Toughness, QW-170	Side Bend, QW-160
1	≤½ in. (≤12 mm)	1 to 2	2 <i>W</i>	2	3	4	4	6	6
2 to 8	<1 in. (<25 mm)	2 to 2 <i>B</i>	2 <i>W</i>	2	3	4	4	6	6
2 to 8	1 in. to 2 in. (25 mm to 50 mm)	2 to 2 <i>B</i>	2 <i>W</i>	2	6	4	4	6	6
>8	≥2 in. (≥50 mm)	2 to unlimited	Unlimited	2	6	4	4	9	6

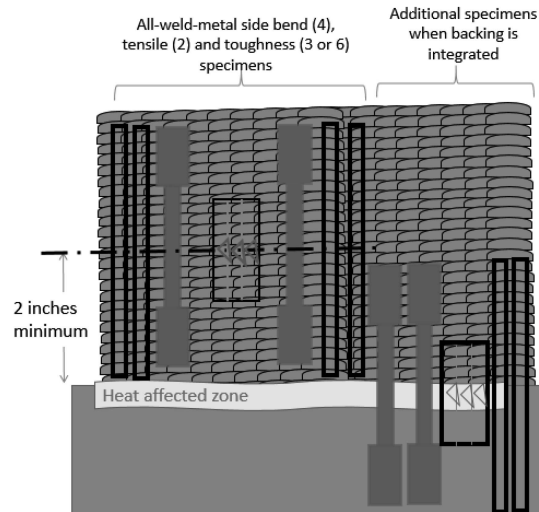
Figure 1
Specimen Locations for Layer Widths Less Than or Equal to 1/2 in. (12 mm)



GENERAL NOTES:

- (a) Weld specimen is shown with one bead per layer. Multiple weld beads per layer are permitted with the layer width and number of weld beads per layer qualified in accordance with Table 2.
- (b) Three Charpy V-notch toughness specimens shall be located with the notch at approximately 1/16 in. (2 mm) from the edge of the weld beads.
- (c) With integrated backing, an additional three Charpy V-notch toughness specimens shall be located with the notch within the heat-affected zone.
- (d) Full-width bend and tensile specimens shall be tested and examined.
- (e) The order of specimen removal is not mandatory.

Figure 2
Specimen Locations for Layer Widths Greater Than 1/2 in. (12 mm)



GENERAL NOTES:

- (a) Three Charpy V-notch toughness specimens shall be located with the notch at approximately 1/16 in. (2 mm) from the edge of the weld beads. For layer widths greater than 1/2 in. (12 mm), an additional three Charpy V-notch toughness specimens shall be located with the notch at the middle of the weld beads.
- (b) With integrated backing, an additional three Charpy V-notch toughness specimens shall be located with the notch within the heat-affected zone.
- (c) Full-width bend and tensile specimens shall be tested and examined.
- (d) The order of specimen removal is not mandatory.

Case 3021
Alternate WPS Qualification

(25)

Section I

ANNULLED

December 28, 2024

Reason: No longer needed.

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Case 3022-1

Waiver of Production Impact Testing For Category B Welded Joints

Section VIII, Division 1

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may production impact tests required per UG-84(i)(1) be waived for Category B welded joints for a Section VIII, Division 1 pressure vessel?

Reply: It is the opinion of the Committee that production impact tests per UG-84(i)(1) may be waived for Category B welded joints for a Section VIII, Division 1 pressure vessel, provided the following requirements are met:

(a) Materials shall be limited to P. No. 1, Groups 1 and 2 listed in Table UCS-23 with the specifications covered by SA-20/SA-20M for plate product form or SA-530/SA-530M for pipe product form.

(b) The minimum design metal temperature (MDMT) at maximum allowable working pressure recorded on the nameplate shall be no colder than -55°F (-48°C).

(c) The maximum applied longitudinal stress in Category B welded joints shall not exceed 50% of the applied hoop stress for sustained loading conditions and 60% of applied hoop stress when combined with earthquake or wind loading as per UG-23(d), respectively.

(d) The impact test exemption temperature for Category B welded joints determined per Figure UCS-66.2 shall be no warmer than MDMT stamped on the nameplate. The required thickness in corroded condition t_r in Figure UCS-66.2 is the thickness calculated for the Category B welded joint due to the maximum longitudinal stress from the maximum design pressure combined with applicable UG-22 loads.

(e) This Case is not permissible for angle joints in Category B welds.

(f) The governing thickness for welded component shall not exceed 3.75 in. (95.3 mm).

(g) This Case is not permissible for lethal service.

(h) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3023

Use of an Automatic Pressure Decay Test for Part HLW Water Heaters

Section IV

Approval Date: June 24, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an automatic pressure decay test be used in lieu of a hydrostatic test required by HLW-505 in the construction of Section IV, Part HLW water heaters?

Reply: It is the opinion of the Committee that an automatic pressure decay test may be used in lieu of a hydrostatic test required by HLW-505 in the construction of Section IV, Part HLW water heaters, provided the following requirements are met:

(a) The test method shall be based on a pressure decay measurement performed in accordance with the requirements of the standard practice ASTM E2930-13 and Section V, Article 10, Mandatory Appendix VI.

(b) A written procedure describing this test method shall be included in the Manufacturer's Quality Control System and accepted by the Authorized Inspector.

(c) The maximum water volume of the water heater subjected to this test shall not exceed 1.0 ft³ (0.028 m³).

(d)) The MAWP of the water heater subjected to this test shall not exceed 160 psi (1103 kPa).

(e) The required test pressure shall be greater of 38 psi (262 kPa) or 1.1 times the MAWP.

(f) The maximum material thickness of any component part shall not exceed 1/2 in. (12.7 mm).

(g)) No component of the water heater subjected to this test shall be constructed of cast iron or cast aluminum.

(h) The surface of the water heater to be tested shall be dry inside and outside with no visible signs of moisture.

(i) The water heater to be tested and applied test equipment shall be maintained at least at a metal temperature equal to 60°F (16°C) during the test. In addition, the maximum temperature difference between the unit to be tested, test equipment and test air shall be not greater than 5°F (3°C).

(j) Nitrogen or clean, dry, oil-free air shall be used.

(k) Safety measures according to the local jurisdictional requirements shall be applied to protect personnel conducting and/or witnessing this test. This Case does not address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this Case to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(l) All other applicable requirements of Section IV, Part HLW shall be met.

(m) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3024

Ni-Cr-Co-Mo-Ti Precipitation Hardened Alloy UNS N07208

Section I; Section VIII, Division 1

Approval Date: July 22, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may Ni-Cr-Co-Mo-Ti Precipitation Hardened Alloy (UNS N07208) wrought bar, fittings, forgings, forgings stock, plate, sheet, strip, seamless pipe and tube, and welded pipe and tube be used in welded and nonwelded construction under the rules of Section I and Section VIII, Division 1?

Reply: It is the opinion of the Committee that Ni-Cr-Co-Mo-Ti Precipitation Hardened Alloy UNS N07208 material, as described in the Inquiry, may be used in welded and nonwelded construction under the rules of Section I and Section VIII, Division 1, provided the following additional requirements are met:

(a) The various product forms for this alloy shall conform to the specifications listed in [Table 1](#).

(b) The chemical composition of this alloy shall conform to [Table 2](#).

(c) The maximum design temperature is 1,600°F (870°C).

(d) The material shall be

(1) solution annealed within the temperature range of 2,000°F to 2,125°F (1 095°C to 1 160°C) for 30 min per 1 in. (25 mm) of thickness followed by water quenching or rapid air cooling; and then

(2) aged within the temperature range of 1,450°F to 1,550°F (790°C to 840°C) for 4 hr minimum followed by air cooling.

(e) As an alternative to (d), the material may be supplied in the solution annealed condition, provided the following requirements are met:

(1) The material supplied in the solution annealed condition shall have a maximum tensile strength of 150.0 ksi (1 035 MPa) and a maximum yield strength of 100.0 ksi (690 MPa). It shall also have a minimum elongation of 30% in 2 in. (50 mm) or 4D (refers to diameter of the tensile specimen) gage length.

(2) The material supplier shall mark the material as solution annealed.

(3) The heat treatment requirements of (d)(2) shall be performed on a sample from the material to demonstrate compliance with this Case. The extent of testing shall be as defined in the specifications listed in [Table 1](#).

(4) The material shall be aged and air-cooled in accordance with (d)(2) by the Manufacturer to obtain the mechanical properties of this Case. Local heat treatment is not permitted.

(f) The density is 0.30 lb/in.³ (8 300 kg/m³).

(g) Poisson's ratio is 0.31.

(h) The room temperature tensile properties of this alloy shall be those listed in [Tables 3](#) and [3M](#).

(i) The maximum allowable stress values for the material shall be those listed in [Tables 4](#) and [4M](#).

(j) The elevated temperature tensile strength values for the material shall be those listed in [Tables 5](#) and [5M](#).

(k) The elevated temperature yield strength values for the material shall be those listed in [Tables 6](#) and [6M](#).

(l) [Tables 7](#) and [7M](#) list the thermal diffusivity.

(m) [Tables 8](#) and [8M](#) list thermal conductivity.

(n) [Tables 9](#) and [9M](#) list dynamic modulus of elasticity.

(o) [Tables 10](#) and [10M](#) list mean coefficient of thermal expansion.

(p) Postweld heat treatment (PWHT) for this material is mandatory. The postweld heat treatment shall be performed for 4 hr minimum between 1,450°F to 1,550°F (790°C to 840°C). Solution annealing prior to PWHT is not required.

(q) Welding procedure and performance qualification shall be conducted in accordance with Section IX. Separate welding procedure qualification is required for this material. For performance qualifications, this material shall be considered P-No. 43. Welding procedure qualifications shall be performed with material in the heat-treated condition planned for production welding, which may be either solution annealed-aged-welded-postweld heat treated or solution annealed-welded-postweld heat treated. If welding of both heat-treat conditions is planned, qualifications for both conditions shall be required. The heat-treated condition shall be noted on the PQR and WPS used for construction. When welding this alloy to itself, the filler metal shall be SFA-5.14/SFA-5.14M ERNiCrCoMo-2 (UNS N07208). Welding shall be limited to bare solid wire filler metals using either the GTAW or GMAW welding processes. The

guided bend test required by Section IX, QW-160 shall be performed using a $4t$ maximum bend radius.

(r) For Section I applications

(1) In accordance with PG-19, calculations of forming strains shall be made for the component. The component shall be heat treated in accordance with the requirements specified in (d) after any of the following:

(-a) cold forming that produces forming strains in excess of 10%

(-b) swages, upsets, or flares

(-c) hot forming of this material

No localized heat treatments to relax forming strains may be performed. The entire affected component or the part shall be included in both heat treatments.

(2) The rules of PG-26 shall apply for temperatures at and above 1,100°F (593°C). Weld strength reduction factors listed in Table 11 shall apply.

(3) In accordance with PG-27, the temperature-dependent design value y shall be as follows:

(-a) 1,150°F (620°C) and below: 0.4

(-b) 1,200°F (650°C): 0.5

(-c) above 1,200°F (650°C): 0.7

(s) For Section VIII, Division 1 applications

(1) The rules of Subsection C, Part UNF for nickel alloys shall apply except impact testing exemptions from UNF-65 are not applicable.

(2) For welded fittings, welded pipe and tube, the maximum allowable stress values shall be multiplied by a weld strength reduction factor of 0.85.

(3) Impact testing is required when minimum design metal temperature (MDMT) is colder than 70°F (20°C). Impact testing of base metal, weld metal and heat affected zone shall be conducted using the rules of UG-84. The minimum lateral expansion of each specimen shall be no less than 0.015 in. (0.38 mm) and the test temperature shall be no warmer than the specified MDMT. Production impact testing requirements are mandatory per UG-84(i).

(4) In accordance with UNF-79, the component shall be heat treated in accordance with the requirements specified in (d) after any of the following:

(-a) cold forming that produces forming strains in excess of 10%

(-b) swages, upsets, or flares

(-c) hot forming of this material

No localized heat treatments to relax forming strains may be performed. The entire affected component or the part shall be included in both heat treatments.

(t) External pressure design is prohibited.

(u) This Case number shall appear in the marking and certification for the material and on the Manufacturer's Data Report.

**Table 1
ASTM Specifications**

Specification	Product
ASTM B366/B366M-19	Fittings
ASTM B619/B619M-19	Welded pipe
ASTM B637-18	Bar, forging, forging stock
ASTM B670-07(2018)	Plate, sheet, strip
ASTM B983-16e1	Seamless pipe or tube
ASTM B1007-17	Welded tube

**Table 2
Chemical Requirements**

Element	Nominal Composition, %
Ni	Remainder
Cr	18.5–20.5
Fe	1.5 max.
Mn	0.3 max.
Co	9.0–11.0
C	0.04–0.08
Si	0.15 max.
S	0.015 max.
P	0.015 max.
Al	1.38–1.65
B	0.003–0.010
Cu	0.1 max.
Mo	8.0–9.0
Ta	0.1 max.
Ti	1.9–2.3
Nb	0.2 max.
W	0.5 max.
Zr	0.02 max.

**Table 3
Tensile Properties (Room Temperature)**

Minimum Tensile Strength, ksi	Minimum Yield Strength, ksi	Minimum Elongation, %
155	90	20

**Table 3M
Tensile Properties (Room Temperature)**

Minimum Tensile Strength, MPa	Minimum Yield Strength, MPa	Minimum Elongation, %
1070	620	20

Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress Value, ksi
100	44.3
200	44.3
300	44.3
400	44.3
500	44.1
600	43.3
650	43.1
700	42.9
750	42.7
800	42.6
850	42.5
900	42.5
950	42.4
1,000	42.3
1,050	42.0
1,100	41.7
1,150	39.9 [Note (1)]
1,200	32.6 [Note (1)]
1,250	26.0 [Note (1)]
1,300	20.3 [Note (1)]
1,350	15.4 [Note (1)]
1,400	11.3 [Note (1)]
1,450	7.8 [Note (1)]
1,500	5.2 [Note (1)]
1,550	2.4 [Note (1)]
1,600	1.6 [Note (1)]

NOTE: (1) These stress values are obtained from time-dependent properties.

Table 4M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress Value, MPa
40	305
65	305
100	305
125	305
150	305
175	305
200	305
225	305
250	305
275	302
300	300
325	298
350	297
375	295
400	294
425	294
450	293
475	293
500	293
525	292
550	291
575	289
600	287
625	268 [Note (1)]
650	223 [Note (1)]
675	182 [Note (1)]
700	146 [Note (1)]
725	115 [Note (1)]
750	87 [Note (1)]
775	65 [Note (1)]
800	45 [Note (1)]
825	22 [Note (1)]
850	15 [Note (1)]
875	10 [Note (1)], [Note (2)]

NOTES:

- (1) These stress values are obtained from time-dependent properties.
- (2) The maximum use temperature shall be 870°C. Datum for 875°C temperature is provided for interpolation purposes.

Table 5
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °F	S_u Values, ksi
100	155.0
200	155.0
300	155.0
400	155.0
500	154.4
600	151.7
650	150.7
700	150.0
750	149.5
800	149.2
850	148.9
900	148.7
950	148.4
1,000	147.9
1,050	147.2
1,100	146.0
1,150	144.4
1,200	142.1
1,250	139.0
1,300	135.0
1,350	130.0
1,400	123.8
1,450	116.3
1,500	107.3
1,550	96.8
1,600	84.6

Table 5M
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °C	S_u Values, MPa
40	1069
65	1069
100	1069
125	1069
150	1069
175	1069
200	1069
225	1069
250	1069
275	1059
300	1050
325	1043
350	1038
375	1034
400	1031
425	1029
450	1027
475	1026
500	1024
525	1022
550	1018
575	1012
600	1004
625	993
650	979
675	960
700	936
725	906
750	870
775	827
800	776
825	717
850	649
875	571 [Note (1)]

NOTE: (1) The maximum use temperature shall be 870°C. Datum for 875°C temperature is provided for interpolation purposes.

Table 6
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °F	S_y Values, ksi
100	90.0
200	83.1
300	81.1
400	80.3
500	79.8
600	79.2
650	78.8
700	78.3
750	77.9
800	77.5
850	77.1
900	76.8
950	76.5
1,000	76.4
1,050	76.4
1,100	76.4
1,150	76.4
1,200	76.4
1,250	76.4
1,300	76.4
1,350	76.1
1,400	75.0
1,450	73.2
1,500	70.2
1,550	65.8
1,600	59.7

Table 6M
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °C	S_y Values, MPa
40	621
65	587
100	571
125	564
150	559
175	556
200	554
225	552
250	551
275	549
300	547
325	545
350	542
375	540
400	537
425	534
450	532
475	530
500	528
525	527
550	527
575	527
600	527
625	527
650	527
675	527
700	527
725	526
750	521
775	511
800	497
825	475
850	445
875	404 [Note (1)]

NOTE: (1) The maximum use temperature shall be 870°C. Datum for 875°C temperature is provided for interpolation purposes.

Table 7
Thermal Diffusivity

Temperature, °F	Thermal Diffusivity, ft ² /hr
70	0.111
100	0.113
125	0.114
150	0.116
200	0.119
250	0.122
300	0.125
350	0.129
400	0.131
450	0.135
500	0.138
550	0.140
600	0.144
650	0.146
700	0.148
750	0.151
800	0.154
850	0.157
900	0.160
950	0.162
1,000	0.165
1,050	0.168
1,100	0.171
1,150	0.174
1,200	0.175
1,250	0.179
1,300	0.182
1,350	0.183
1,400	0.190
1,450	0.186
1,500	0.187
1,550	0.187
1,600	0.182
1,650	0.186
1,700	0.185
1,750	0.185
1,800	0.186
1,850	0.185
1,900	0.186
1,950	0.190
2,000	0.195

Table 7M
Thermal Diffusivity

Temperature, °C	Thermal Diffusivity, 10 ⁻⁶ m ² /s
20	2.86
50	2.94
75	3.01
100	3.09
125	3.16
150	3.24
175	3.32
200	3.39
225	3.46
250	3.52
275	3.59
300	3.65
325	3.71
350	3.78
375	3.84
400	3.90
425	3.96
450	4.03
475	4.10
500	4.17
525	4.23
550	4.30
575	4.37
600	4.44
625	4.51
650	4.57
675	4.63
700	4.68
725	4.72
750	4.76
775	4.79
800	4.81
825	4.82
850	4.82
875	4.81
900	4.80
925	4.79
950	4.77
975	4.76
1000	4.77
1025	4.79
1050	4.84
1075	4.93
1100	5.08

Table 8
Thermal Conductivity

Temperature, °F	Thermal Conductivity, Btu/hr-ft-°F
70	5.9
100	6.1
125	6.2
150	6.3
200	6.6
250	6.9
300	7.2
350	7.4
400	7.7
450	8.0
500	8.2
550	8.5
600	8.7
650	8.9
700	9.2
750	9.4
800	9.6
850	9.9
900	10.1
950	10.4
1,000	10.6
1,050	10.9
1,100	11.1
1,150	11.4
1,200	11.6
1,250	11.9
1,300	12.1
1,350	12.3
1,400	12.5
1,450	12.6
1,500	12.7
1,550	12.8
1,600	12.8
1,650	12.8
1,700	12.8
1,750	12.8
1,800	12.9
1,850	12.9
1,900	13.1
1,950	13.4
2,000	13.8

Table 8M
Thermal Conductivity

Temperature, °C	Thermal Conductivity, W/m·K
20	10.2
50	10.7
75	11.1
100	11.5
125	12.0
150	12.4
175	12.9
200	13.3
225	13.7
250	14.1
275	14.4
300	14.8
325	15.2
350	15.5
375	15.9
400	16.3
425	16.6
450	17.0
475	17.4
500	17.8
525	18.2
550	18.6
575	19.0
600	19.4
625	19.8
650	20.2
675	20.5
700	20.9
725	21.2
750	21.4
775	21.7
800	21.9
825	22.0
850	22.1
875	22.2
900	22.2
925	22.2
950	22.2
975	22.2
1000	22.3
1025	22.5
1050	22.8
1075	23.3
1100	23.8

Table 9
Dynamic Modulus of Elasticity

Temperature, °F	Dynamic Modulus of Elasticity, $\times 10^6$ psi
75	31.6
100	31.4
200	31.0
300	30.6
400	30.1
500	29.6
600	29.2
700	28.7
800	28.1
900	27.6
1,000	27.0
1,100	26.3
1,200	25.6
1,300	24.8
1,400	23.9
1,500	23.0
1,600	22.0
1,700	20.9
1,800	19.7
1,900	18.3
2,000	16.6
2,100	14.7

Table 9M
Dynamic Modulus of Elasticity

Temperature, °C	Dynamic Modulus of Elasticity, $\times 10^3$ MPa
25	218
100	214
150	211
200	208
250	205
300	202
350	199
400	196
450	193
500	189
550	186
600	182
650	177
700	172
750	167
800	161
850	155
900	148
950	140
1000	132
1050	123
1100	114
1150	102

Table 10
Mean Coefficient of Thermal Expansion

Temperature, °F	Mean Coefficient of Thermal Expansion, ×10 ⁻⁶ in./in./°F
70	...
100	6.5
125	6.6
150	6.7
200	6.8
250	6.9
300	6.9
350	6.9
400	7.0
450	7.0
500	7.1
550	7.1
600	7.2
650	7.2
700	7.3
750	7.3
800	7.4
850	7.4
900	7.4
950	7.5
1,000	7.5
1,050	7.5
1,100	7.6
1,150	7.7
1,200	7.8
1,250	7.9
1,300	7.9
1,350	8.0
1,400	8.1
1,450	8.2
1,500	8.4
1,550	8.5
1,600	8.7
1,650	8.8
1,700	9.0
1,750	9.2
1,800	9.3
1,850	9.5
1,900	9.5
1,950	9.6
2,000	9.6

Table 10M
Mean Coefficient of Thermal Expansion

Temperature, °C	Mean Coefficient of Thermal Expansion, ×10 ⁻⁶ mm/mm/°C
20	11.6
50	11.9
75	12.1
100	12.3
125	12.4
150	12.5
175	12.6
200	12.6
225	12.7
250	12.8
275	12.8
300	12.9
325	13
350	13
375	13.1
400	13.2
425	13.3
450	13.3
475	13.4
500	13.5
525	13.6
550	13.6
575	13.7
600	13.8
625	13.9
650	14
675	14.1
700	14.3
725	14.4
750	14.6
775	14.8
800	15
825	15.2
850	15.4
875	15.7
900	16
925	16.2
950	16.5
975	16.8
1000	17
1025	17.2
1050	17.3
1075	17.3
1100	17.3

Table 11
Weld Strength Reduction Factor (WSRF) to Be Applied
When Calculating Maximum Allowable Working
Pressure or Minimum Required Thickness of Components
Fabricated With a Longitudinal Seam Weld

Temperature, °F	Temperature, °C	Weld Strength Reduction Factor
1,100	593	0.99
1,150	621	0.93
1,200	649	0.93
1,250	677	0.93
1,300	704	0.93
1,350	732	0.93
1,400	760	0.93
1,450	788	0.93
1,500	816	0.86
1,550	843	0.86
1,600	871	0.84

Case 3025

Alternative Minimum Thickness Requirements for Part HLW Water Heaters and Storage Tanks

Section IV

Approval Date: June 24, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions it is permissible to apply the minimum thickness requirements specified in HF-301.1 in lieu of the minimum thickness requirements specified in HLW-302 in the construction of Section IV, Part HLW water heaters and storage tanks?

Reply: It is the opinion of the Committee that the minimum thickness requirements specified in HF-301.1 may be used in lieu of the minimum thickness requirements specified in HLW-302 in the construction of

Section IV, Part HLW water heaters and storage tanks, provided the following requirements are met:

(a) The minimum thickness for pressure shall not be less than required by the applicable design formulas, nor less than those thicknesses established by proof testing, as provided in Section IV, Part HLW.

(b) The applied materials shall be limited to ferrous plates or sheets permitted by Section IV, Part HLW or by applicable Section IV Code Cases. If the provisions of HF-301.1(c) are used, the applied materials shall be additionally limited to alloy steel plates or sheets.

(c) All other applicable requirements of Section IV, Part HLW shall be met.

(d) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3026

Use of Manual Ultrasonic Examination of Welds

Section I

Approval Date: July 15, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use manual scanning with no scanner equipment (i.e., without the use of automated scanning equipment) for ultrasonic (UT) examinations in accordance with Section V, Article 4 in lieu of the requirements of Section I, PW-52 when examining welds in Section I components?

Reply: It is the opinion of the Committee that ultrasonic examinations using the manual scanning technique in accordance with Section V, Article 4, T-453(a) is acceptable in lieu of the requirements of PW-52.1 of Section I, provided the following requirements are met:

(a) The acceptance criteria shall be in accordance with Section I, PW-52.3.

(b) The Manufacturer's report for the UT examination shall be in accordance with Section I, PW-52.2.

(c) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3027

Use of UNS S43932 Ferritic Stainless Steel in SA-240/SA-240M Plate, Sheet, Strip, and in SA-268/SA-268M Welded and Seamless Tube

Section IV

Approval Date: August 9, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S43932 ferritic stainless steel plate, sheet, and strip conforming to SA-240/SA-240M be used in HLW construction and seamless and welded tubing conforming to SA-268/SA-268M in H and HLW construction?

Reply: It is the opinion of the Committee that UNS S43932 ferritic stainless steel plate, sheet, and strip conforming to SA-240/SA-240M may be used in HLW construction and seamless and welded tubing conforming to SA-268/SA-268M may be used in H and HLW construction, provided the following requirements are met:

(a) The maximum allowable stress values shall be as listed in [Tables 1, 1M, 2, and 2M](#).

(b) Welding procedure and performance qualification shall be conducted in accordance with Section IX. Those materials shall be considered P-No. 7, Group No. 2.

(c) For external pressure Section II, Part D, Figure CS-2 shall be used.

(d) The maximum design temperature shall be 500°F (260°C).

(e) All other applicable requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values
for SA-268 Welded and Seamless Tube

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]	
	H	HLW
100	12.0	15.0
200	12.0	15.0
300	11.6	14.5
400	11.3	14.1
500	11.0	13.8

NOTE: (1) For welded tube, the maximum allowable stress values shall be multiplied by a factor of 0.85.

Table 1M
Maximum Allowable Stress Values
for SA-268M Welded and Seamless Tube

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]	
	H	HLW
40	82.8	104
100	82.6	103
150	79.8	99.8
200	77.8	97.3
250	76.4	95.5
275 [Note (2)]	75.6	94.5

NOTES:

- (1) For welded tube, the maximum allowable stress values shall be multiplied by a factor of 0.85.
- (2) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

Table 2
Maximum Allowable Stress Values
for SA-240 Plate, Sheet, and Strip

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values for HLW, ksi [Note (1)]
100	15.0
200	15.0
300	14.5
400	14.1
500	13.8

NOTE: (1) The maximum thickness of material covered by this Table is $\frac{3}{8}$ in.

Table 2M
Maximum Allowable Stress Values
for SA-240M Plate, Sheet, and Strip

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values for HLW, MPa [Note (1)]
40	104
100	103
150	99.8
200	97.3
250	95.5
275 [Note (2)]	94.5

NOTES:

- (1) The maximum thickness of material covered by this Table is 10 mm.
- (2) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

Case 3028

Use of PRT I Designator

Section I

Approval Date: July 15, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use PRT I Designator with the ASME Certification Mark for Section I fabricated parts in lieu of the PRT Designator in accordance with the requirements of ASME CA-1-2020?

Reply: It is the opinion of the Committee that the PRT I Designator may be used with the ASME Certification Mark for Section I fabricated parts in lieu of the PRT Designator in accordance with the requirements of ASME CA-1-2020. This Case number shall be shown on the Form P-4, Manufacturer's Partial Data Report.

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Case 3029

Allowable Compressive Stress in the Time-Dependent Regime

Section VIII, Division 2

Approval Date: June 24, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May components operating in the time-dependent regime be designed for allowable compressive stress in Section VIII, Division 2 using the procedures outlined in this Case?

Reply: It is the opinion of the Committee that components operating in the time-dependent regime may be designed for allowable compressive stress in Section VIII, Division 2 using the procedures outlined in this Case.

1 NOMENCLATURE

A_0, A_1, A_2, A_3, A_4 = Omega creep model damage parameter constants from Nonmandatory [Appendix A](#)

B_0, B_1, B_2, B_3, B_4 = Omega Creep Model Strain Rate Constants from Nonmandatory [Appendix A](#)

\bar{c} = coefficient in C_x accounting for length effects (or stiffeners) in axial buckling

C_h = coefficient in elastic external pressure equation; this coefficient is an analytical equation that replaces Section II, Part D, Figure G, i.e., analytical equation for Sturms K factor charts

C_x = coefficient in elastic axial buckling equation that includes imperfection knock-down factor for ring stiffened shells under axial compression (can also be used for unstiffened cylinders by setting $\bar{c} = 1$)

D_1, D_2, D_3, D_4 = Time Independent Tangent Modulus Parameters from Section VIII, Division 2, Annex 3-D.5.1

D_0 = outside diameter of shell

E = elastic modulus

E_t = tangent modulus

F_{he} = predicted elastic hoop stress for external pressure with imperfection knockdowns

F_{heth} = theoretical elastic hoop stress for external pressure without imperfection knock-downs

F_{ic} = predicted inelastic buckling stress (elastic stress multiplied by plastic reduction factor)

F_{ich} = inelastic hoop buckling stress

F_{icx} = inelastic axial buckling stress

FS = design factor (design margin)

F_{xe} = predicted elastic axial buckling stress with imperfection knockdowns

F_{xeth} = theoretical elastic axial buckling stress without imperfection knockdowns

L = unstiffened length of cylinder

$$M_x = \frac{L}{\sqrt{\frac{D_0 t}{2}}}$$

$S_{I, IID}$ = $\log_{10}(1.5 * S_{all, IID})$

$S_{all, IID}$ = Section II, Part D allowable stress

S_l = $\log(\sigma_{cr, TD})$

t = shell thickness

T_{design} = design temperature (per the User's design Specification)

t_{design} = 100,000 hr

σ_{design} = design stress (component stress due to design loads specified in the User's Design Specification)

The following subscripts apply:

TD = time dependent

TI = time independent

NOTES:

(1) The yield and ultimate strengths used in these equations are calculated using the trend curves in [Nonmandatory Appendix A](#) of this Case.

(2) The units to be used in this Case are restricted to the following:

(a) length: inch

(b) modulus (elastic and inelastic): ksi

(c) stress: ksi

(d) temperature: °F

2 LOCAL BUCKLING (RING STIFFENED) OR GENERAL BUCKLING (UNSTIFFENED) DUE TO AXIAL COMPRESSION IN CYLINDERS

Step 1. Establish an outside diameter D_0 , a thickness t , and M_x .

$$M_x = \frac{L}{\sqrt{\frac{D_0}{2}t}}$$

Step 2. Calculate theoretical elastic buckling stress F_{xeth} .

$$F_{xeth} = 1.21E \left(\frac{t}{D_0} \right)$$

Step 3. Calculate imperfection knockdown factor c_x .

$$c_x = \frac{338\bar{c}}{389 + \frac{D_0}{t}} \text{ for } \frac{D_0}{t} \leq 1, 247 \text{ (not to exceed 0.744)}$$

or

$$c_x = 0.207\bar{c} \text{ for } 1, 247 \leq \frac{D_0}{t} \leq 2, 000$$

where

$$\begin{aligned} \bar{c} &= 2.64 & \text{for } M_x \leq 1.5 \\ \bar{c} &= \frac{3.13}{M_x^{0.42}} & \text{for } 1.5 < M_x < 15 \\ \bar{c} &= 1 & \text{for } M_x > 15 \end{aligned}$$

Step 4. Calculate predicted elastic buckling stress with imperfection, F_{xe} .

$$F_{xe} = c_x F_{xeth} = c_x 1.21E \left(\frac{t}{D_0} \right)$$

Step 5. Calculate margins on time independent buckling.

(a) Solve for Critical Time Independent Buckling Stress, $\sigma_{cr, TI}$.

$$\frac{F_{xe}}{E} - \left[\frac{\frac{\sigma_{cr, TI}}{1}}{\left\{ \frac{1}{E} + D_1 + D_2 + D_3 + D_4 \right\}} \right] = 0$$

NOTE: The values of D_1, D_2, D_3, D_4 are functions of stress and need to be explicitly written out as such (they are not constants in the evaluation).

(b) Calculate allowable time-independent axial stress, $F_{xa, TI}$.

$$F_{xa, TI} = \frac{\sigma_{cr, TI}}{FS_{TI}}$$

where

$$\begin{aligned} FS_{TI} &= 2.0 & \text{for } \frac{\sigma_{cr, TI}}{S_y} < 0.55 \\ &= 2.407 - 0.741 \left(\frac{\sigma_{cr, TI}}{S_y} \right) & \text{for } 0.55 < \frac{\sigma_{cr, TI}}{S_y} < 1 \\ &= 1.667 & \text{for } \frac{\sigma_{cr, TI}}{S_y} \geq 1 \end{aligned}$$

(c) Check margins on design Stress with regards to Time Independent Allowable. The following condition must be satisfied before proceeding to Step 6. If not, this is a time independent buckling problem and the design loads and/or geometry should be modified.

$$\frac{\sigma_{design}}{F_{xa, TI}} \leq 1$$

Step 6. Calculate the average critical stress to buckle at 100,000 hr. Critical time-dependent stress to buckle is given by solving for $\sigma_{cr, TD}$ from the equation below:

$$\frac{F_{xe}}{E} - \left[\frac{\frac{\sigma_{cr, TD}}{1}}{\left\{ \frac{1}{E} + D_1 + D_2 + D_3 + D_4 + \left[\frac{1}{\Omega} \ln \left(1 - \epsilon_c 0^t \Omega t_{design} \right) \frac{(B_2 + 2B_3 S_l + 3B_4 S_l^2)}{\sigma_{cr, TD}(T + 460)} \right] + \frac{\epsilon_c 0^t design}{(1 - \epsilon_c 0^t design) \sigma_{cr, TD}(T + 460)} \left[\left(B_2 - A_2 \right) + 2(B_3 - A_3) S_l + 3(B_4 - A_4) S_l^2 \right] \right\}} \right] = 0$$

where

$$\log_{10} \dot{\epsilon}_c 0 = - \left\{ \left(A_0 + \Delta_{\Omega}^{sr} \right) + \left(\frac{A_1 + A_2 S_l + A_3 S_l^2 + A_4 S_l^3}{T_{design} + 460} \right) \right\}$$

$$\log_{10}\Omega = B_0 + \left(\frac{B_1 + B_2 S_l + B_3 S_l^2 + A_4 S_l^3}{T_{\text{design}} + 460} \right)$$

$$\Delta_{\Omega}^{\sigma} = (S + B_0 - A_0) + \left(\frac{\begin{aligned} &(B_1 - A_1) + (B_2 - A_2)S_{l,\text{IID}} + (B_3 - A_3)S_{l,\text{IID}}^2 \\ &+ (B_4 - A_4)S_{l,\text{IID}}^3 \end{aligned}}{T_{\text{design}} + 460} \right)$$

NOTE: The values of $D_1, D_2, D_3, D_4, \dot{\epsilon}_{c0}$, and Ω are not constants in the evaluation and must be explicitly written out as functions of critical stress during the iterative solution.

Step 7. Calculate time dependent allowable stress to Buckle, $F_{xa,\text{TD}}$ at 100,000 hr.

$$F_{xa,\text{TD}} = \frac{\sigma_{cr,\text{TD}}}{FS_{\text{TD}}}$$

where $FS_{\text{TD}} = 1.5$ is the design factor for time-dependent buckling.

Step 8. Verify acceptance. If $\sigma_{\text{design}} \leq F_{xa,\text{TD}}$ the design is acceptable; if not, the loads and/or geometry should be modified.

3 LOCAL BUCKLING (RING STIFFENED) OR GENERAL BUCKLING (UNSTIFFENED) DUE TO EXTERNAL PRESSURE IN CYLINDERS

Step 1.

(a) Establish an outside diameter D_0 , a thickness t , operating time T , and M_x .

$$M_x = \frac{L}{\sqrt{\frac{D_0}{2}t}}$$

(b) Calculate theoretical elastic buckling stress F_{heth} .

$$F_{heth} = 2.0C_h E \left(\frac{t}{D_0} \right)$$

where

$$\begin{aligned} C_h &= 0.55 \frac{t}{D_0} && \text{for } M_x \geq 2 \left(\frac{D_0}{t} \right)^{0.94} \\ &= 1.12M_x^{-1.058} && \text{for } 13 \leq M_x \leq 2 \left(\frac{D_0}{t} \right)^{0.94} \\ &= \frac{0.92}{M_x - 0.579} && \text{for } 1.5 \leq M_x \leq 13 \\ &= 1.0 && \text{for } M_x \leq 1.5 \end{aligned}$$

Step 2. Calculate predicted elastic buckling stress with imperfection, F_{he} .

$$F_{he} = 0.8F_{heth} = 1.6C_h E \left(\frac{t}{D_0} \right)$$

Step 3. Calculate margins on time-independent buckling.

(a) Solve for critical time-independent buckling stress, $\sigma_{cr,\text{TI}}$.

$$\frac{F_{he}}{E} - \left[\frac{\sigma_{cr,\text{TI}}}{\frac{1}{\left\{ \frac{1}{E} + D_1 + D_2 + D_3 + D_4 \right\}}} \right] = 0$$

(b) Calculate allowable time-independent hoop stress, $F_{ha,\text{TI}}$.

$$F_{ha,\text{TI}} = \frac{\sigma_{cr,\text{TI}}}{FS}$$

where

$$\begin{aligned} FS_{\text{TI}} &= 2.0 && \text{for } \frac{\sigma_{cr,\text{TI}}}{S_y} < 0.55 \\ &= 2.407 - 0.741 \left(\frac{\sigma_{cr,\text{TI}}}{S_y} \right) && \text{for } 0.55 < \frac{\sigma_{cr,\text{TI}}}{S_y} < 1 \\ &= 1.667 && \text{for } \frac{\sigma_{cr,\text{TI}}}{S_y} \geq 1 \end{aligned}$$

(c) Check margins on operating stress with regards to time-independent allowable. The following condition must be satisfied before proceeding to [Step 4](#). If not, this is a time independent buckling problem and the design loads and/or geometry should be modified.

$$\frac{\sigma_{\text{design}}}{F_{ha,\text{TI}}} \leq 1$$

Step 4. Calculate the average critical stress to buckle when $t = 100,000$ hr. Critical time-dependent stress to buckle is given by solving for $\sigma_{cr,\text{TD}}$ from the equation below:

$$\frac{F_{xe}}{E} - \frac{\sigma_{cr,TD}}{1} = 0$$

$$\left\{ \frac{1}{E} + D_1 + D_2 + D_3 + D_4 \right.$$

$$+ \left[\frac{1}{\Omega} \ln \left(1 - \epsilon_{c0} \Omega t_{design} \frac{(B_2 + 2B_3 S_l + 3B_4 S_l^2)}{\sigma(T + 460)} \right) \right]$$

$$+ \frac{\epsilon_{c0} t_{design}}{(1 - \epsilon_{c0} \Omega t_{design}) \sigma(T + 460)} \left[(B_2 - A_2) \right.$$

$$\left. + 2(B_3 - A_3) S_l + 3(B_4 - A_4) S_l^2 \right]$$

Step 5. Calculate time-dependent allowable stress to buckle at 100,000 hr, $F_{ha,TD}$

$$F_{ha,TD} = \frac{\sigma_{cr,TD}}{FS_{TD}}$$

where $FS_{TD} = 1.5$ is the design factor for time-dependent buckling.

Step 6. Verify acceptance. If $\sigma_{design} \leq F_{ha,TD}$ the design is acceptable; if not, the loads and/or geometry should be modified.

4 REPORT

This Case number shall be shown on the Manufacturer's Data Report.

NONMANDATORY APPENDIX A MATERIAL PROPERTIES

Table A-1
Yield Strength at Temperature $S_{y,T}$ (ksi, °F)

Material	S_y , ksi	T_{min} , °F	T_{max} , °F	C_0	C_1	C_2	C_3	C_4	C_5
Carbon steel	≤40	70	1,050	1.110274	-1.952789 E-03	7.386921 E-06	-1.485792 E-08	1.322039 E-11	-4.312526 E-15
C-½Mo	28	70	1,200	1.041915	-5.803618 E-04	2.323549 E-07	8.761543 E-10	-1.469796 E-12	5.327452 E-16
1¼Cr -½Mo	30	70	1,200	1.060272	-8.879304 E-04	1.185142 E-06	-9.126022 E-10	2.512551 E-13	-7.008346 E-17
2¼Cr-1Mo	30	70	1,200	1.056469	-9.001587 E-04	1.617049 E-06	-8.729456 E-10	-3.074254 E-14	-7.828849 E-17
5Cr-½Mo	30	70	1,300	1.101864	-1.633481 E-03	3.954630 E-06	-3.866350 E-09	9.307023 E-13	1.281434 E-16
9Cr-1Mo	30	70	1,300	1.101864	-1.633481 E-03	3.954630 E-06	-3.866350 E-09	9.307023 E-13	1.281434 E-16
9Cr-1Mo-V	60	70	1,300	1.078963	-1.269316 E-03	3.244157 E-06	-2.966921 E-09	3.550899 E-13	2.276568 E-16
TP304	30	70	1,500	1.146768	-2.247707 E-03	4.249289 E-06	-4.708893 E-09	2.732244 E-12	-6.538660 E-16
TP316	30	70	1,500	1.101270	-1.458670 E-03	1.481802 E-06	-7.307220 E-10	2.865970 E-13	-1.142740 E-16
TP321	30	70	1,500	1.065340	-8.909010 E-04	1.772090 E-07	5.829130 E-10	-3.340520 E-13	0
TP321H	30	70	1,500	1.07 E+00	-8.91 E-04	1.77 E-07	5.83 E-10	-3.34 E-13	0.00 E+00
TP347	30	70	1,500	1.04 E+00	-5.17 E-04	-7.41 E-07	1.57 E-09	-6.86 E-13	0.00 E+00
TP347H	30	70	1,500	1.04 E+00	-5.50 E-04	-6.16 E-07	1.37 E-09	-5.49 E-13	-3.49 E-17
Alloy 800	30	70	1,500	1.07 E+00	-1.15 E-03	2.81 E-06	-4.32 E-09	3.31 E-12	-9.98 E-16
Alloy 800H	25	70	1,500	1.06 E+00	-7.92 E-04	7.35 E-07	-9.37 E-10	8.65 E-13	-3.07 E-16
Alloy 800HT	25	70	1,500	1.06 E+00	-7.92 E-04	7.35 E-07	-9.37 E-10	8.65 E-13	-3.07 E-16

GENERAL NOTE: The following equation applies to this Table:

$$S_{y,T} = S_y (C_0 + C_1 T + C_2 T^2 + C_3 T^3 + C_4 T^4 + C_5 T^5)$$

where S_y is the specified minimum yield strength at room temperature from Section II, Part D.

Table A-2
Tensile Strength at Temperature $S_{TS,T}$ (ksi, °F)

Material	S_{TS} , ksi	T_{min} , °F	T_{max} , °F	C_0	C_1	C_2	C_3	C_4	C_5
Carbon steel	≤70	70	1,050	0.976706	6.66203 E-04	-6.03804 E-06	1.92536 E-08	-2.40578 E-11	9.72338 E-15
C- $\frac{1}{2}$ Mo	53	70	1,200	1.059525	-8.141874 E-04	8.466784 E-07	2.853639 E-09	-5.349197 E-12	2.137446 E-15
1 $\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo	60	70	1,200	1.006816	7.472253 E-05	-3.219189 E-06	9.855387 E-09	-1.044150 E-11	3.462704 E-15
2 $\frac{1}{4}$ Cr-1Mo	60	70	1,200	1.091114	-1.384682 E-03	2.297709 E-06	7.834140 E-10	-3.043512 E-12	1.072040 E-15
5Cr- $\frac{1}{2}$ Mo	60	70	1,300	1.105143	-1.715655 E-03	4.521454 E-06	-4.705968 E-09	1.226905 E-12	1.587304 E-16
9Cr-1Mo	60	70	1,300	1.105143	-1.715655 E-03	4.521454 E-06	-4.705968 E-09	1.226905 E-12	1.587304 E-16
9Cr-1Mo-V	85	70	1,300	1.083635	-1.363617 E-03	3.696590 E-06	-3.901765 E-09	9.603436 E-13	1.349062 E-16
TP304	75	70	1,500	1.128241	-1.982862 E-03	3.735230 E-06	-2.568024 E-09	2.172525 E-13	1.657173 E-16
TP316	75	70	1,500	1.078890	-1.243150 E-03	2.452110 E-06	-1.604850 E-09	-6.961690 E-14	1.656230 E-16
TP321	75	70	1,500	1.136240 E+00	-2.125410 E-03	4.436980 E-06	-3.480260 E-09	8.061010 E-13	0
TP321H	75	70	1,500	1.14 E+00	-2.13 E-03	4.44 E-06	-3.48 E-09	8.06 E-13	0.00 E+00
TP347	75	70	1,500	1.11 E+00	-1.57 E-03	2.07 E-06	-8.70 E-10	-3.59 E-14	0.00 E+00
TP347H	75	70	1,500	1.10 E+00	-1.51 E-03	1.85 E-06	-5.34 E-10	-2.62 E-13	5.49 E-17
Alloy 800	75	70	1,500	1.06 E+00	-9.41 E-04	2.23 E-06	-2.60 E-09	1.62 E-12	-5.20 E-16
Alloy 800H	65	70	1,500	1.03 E+00	-3.97 E-04	-1.83 E-07	1.49 E-09	-1.36 E-12	2.94 E-16
Alloy 800HT	65	70	1,500	1.03 E+00	-3.97 E-04	-1.83 E-07	1.49 E-09	-1.36 E-12	2.94 E-16

GENERAL NOTE: The following equation applies to this Table:

$$S_{TS,T} = \min \left[S_{TS}, 1.1S_{TS} \left(C_0 + C_1T + C_2T^2 + C_3T^3 + C_4T^4 + C_5T^5 \right), S_{TS} \text{ at } (T - 100) \right]$$

where S_{TS} is the specified minimum yield strength at room temperature from Section II, Part D.

Table A-3
Omega Parameters (WRC 554 Table 3) (ksi, °F)

Material	A₀	A₁	A₂	A₃	A₄	B₀	B₁	B₂	B₃	B₄
Carbon steel	-16.30	38,060	-9,165	1,200	-600	-1.00	3,060	135	-760	247
C- $\frac{1}{2}$ Mo	-19.50	61,000	-49,000	33,000	-8,000	-1.30	4,500	2,000	-4,500	2,000
1 $\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo	-23.50	52,787	-5,965.5	-2,621	-384	-2.65	6,287	1,534.5	-1,871	166
2 $\frac{1}{4}$ Cr-1Mo	-21.86	51,669	-7,597.4	-2,131	-199.3	-1.85	7,195.00	-2,358.00	-127.40	56.20
5Cr- $\frac{1}{2}$ Mo	-22.40	51,668.70	-7,597.37	-2,131.00	-199.27	-1.40	5,019.24	-1,207.62	221.32	89.43
9Cr-1Mo	-22.55	51,473.00	-7,027.30	-1,718.00	-140.60	-2.05	6,410.80	-1,426.60	-69.00	83.80
9Cr-1Mo-V	-34.00	73,285.00	-3,428.00	-3,433.00	-1,146.17	-2.00	7,185.00	-1,231.72	-449.28	205.22
TP304	-19.17	53,762.40	-13,442.40	3,162.60	-1,685.20	-3.40	11,250.00	-5,635.80	3,380.40	-993.60
TP316	-18.90	57,261.50	-18,656.00	3,866.86	-267.16	-4.16	17,176.26	-13,216.00	4,973.80	-67.36
TP321	-19.00	49,425.00	-7,417.00	1,240.00	-1,290.00	-3.40	10,625.00	-3,217.00	1,640.00	-490
TP321H	-18.4	49,425	-7,417	1,240	-1,290	-3.4	10,625	-3,217	1,640	-490
TP347	-18.3	47,140	-5,434	500	-1,128	-3.5	10,000	-800	-100	100
TP347H	-17.7	47,140	-5,434	500	-1,128	-3.65	10,000	-800	-100	100
Alloy 800	-19.4	55,548	-15,877	3,380	-993	-3.6	11,250	-5,635	3,380	-993
Alloy 800H	-18.8	55,548	-15,877	3,380	-993	-3.6	11,250	-5,635	3,380	-993
Alloy 800HT	-20.25	59,445	-14,123	41.42	-0.0405	-3.4	11,195	-4,848.5	1,556	82.42

Case 3030

Use of UNS N08926 Austenitic Stainless Steel Plate, Sheet, and Strip in the Welded Construction of Hot Water Heating Boilers and Hot Water Supply Boilers

Section IV

Approval Date: August 19, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS N08926 austenitic stainless steel in SA-240/SA-240M plate, sheet, and strip be used in the welded construction of Section IV hot water heating boilers and hot water supply boilers?

Reply: It is the opinion of the Committee that UNS N08926 in SA-240/SA-240M plate, sheet, and strip may be used in the welded construction of Section IV hot water heating boilers and hot water supply boilers, provided the following requirements are met:

(a) The maximum allowable stress values shall be as listed in [Tables 1](#) and [1M](#).

(b) Welding procedure and performance qualification shall be conducted in accordance with Section IX. This material shall be considered P. No. 45.

(c) For external pressure Section II, Part D, Figure NFN-12 shall be used.

(d) The maximum design temperature shall be 500°F (260°C).

(e) All other applicable requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

NOTE: This material may utilize the minimum thickness exceptions of HF-301.1(c).

Table 1
Maximum Allowable Stress Values
for SA-240 Plate, Sheet, and Strip

For Metal Temperatures Not Exceeding, °F	UNS N08926, Maximum Allowable Stress Values, ksi
100	18.8
200	18.8
300	18.4
400	17.3
500	16.6

Table 1M
Maximum Allowable Stress Values
for SA-240M Plate, Sheet, and Strip

For Metal Temperatures Not Exceeding, °C	UNS N08926, Maximum Allowable Stress Values, MPa
40	130
100	130
150	126
200	120
250	115
275 [Note (1)]	113

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

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Case 3031

Alternative Method for Protection Against Overpressure

Section I

Approval Date: August 20, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternatives are permissible to achieve overpressure protection for forced flow steam generators with reheaters and attached superheaters in lieu of the requirements of PG-68.4 and PG-68.1?

Reply: It is the opinion of the Committee that protection against overpressure for forced-flow steam generators with no fixed steam and water line with attached superheaters, and reheaters if so equipped, with outlet design temperatures greater than 1,000°F (540°C) may be provided in accordance with the overpressure protection requirements of Section I as modified by the following:

(a) Two or more turbine bypass valves shall be provided, having a total combined relieving capacity equal to some or all of the maximum designed steaming capacity of the boiler as determined by the Manufacturer.

Each turbine bypass valve consists of a main valve and actuator in combination with a control unit. Multiple main valves may be controlled by one control unit. On reaching set pressure, the operating forces on the main valve shall be automatically released so that the main valve discharges its rated capacity. The relieving capacity shall include correcting for the effects of high backpressures that may occur. One or more of the turbine bypass valves shall be set at or below the maximum allowable working pressure. If additional turbine bypass valves are used the highest pressure setting shall not exceed the maximum allowable working pressure by more than 17%. Operation shall be in accordance with PG-72. The system may be designed so that the main valve recloses and prevents a further flow of fluid after normal operating pressure conditions have been restored. On failure of the control unit, the closing force on the main valve shall be immediately released (fail open).

(1) The main valve

(-a) shall consist of the valve through which the discharge capacity is achieved, and an actuator.

(-b) shall be provided with a drain connection at the lowest point where liquid could collect unless other provisions for draining are provided.

(-c) shall incorporate guiding arrangements necessary to insure consistent operation and tightness. The material of guiding surfaces shall be corrosion resistant and shall be selected to minimize the possibility of galling or seizure.

(-d) shall incorporate a seat and disk of suitable material to resist corrosion by the lading fluid.

(-e) shall use materials for bodies, bonnets, and body-to-bonnet bolting in accordance with PG-73.3.3.

(-f) shall open without the assistance of any energy other than that of the fluid to be relieved.

(-g) shall not be of gate or rotating disc-valve type.

(-h) shall only use external energy to create operating forces to be used for closing the main valve.

(-i) shall have an opening force applied in addition to that from the system pressure, such that the valve opens completely with nominally twice the system pressure.

(-j) shall have the relieving capacity certified in accordance with the provisions of PG-69.

(2) The control unit

(-a) shall establish the opening and closing of the main valve.

(-b) shall consist of three redundant individual control paths. Each control path may consist of a pressure tapping line (the line to the pressure sensor), pressure sensor, sensing line (line between the pressure sensor and control module), control module (transforms the signal from the pressure sensor into a force to operate the actuator of the main valve), and control line (line between the control module and the main valve). Each individual control path shall be so designed that the main valve will operate reliably in case of failure of the other individual control paths. At least three control paths, each independent of one another, shall be in operation.

(-c) shall operate the main valve by two control lines. These lines shall not be installed in near proximity to each other in order to avoid simultaneous damage. It is, however, permissible to use only one control line, such that

(-1) the pipe is at least $\frac{5}{8}$ -in. (15-mm) bore to avoid the risk of blockage.

(-2) the pipe is of sufficient thickness to withstand damage from crushing.

(-d) shall permit testing, at any time, of the functionality of all the control paths to verify the performance of the main valve and the functionality of the individual control paths. For tests under operating conditions, a locking system shall ensure that at least two individual control paths stay in operation.

(-e) shall provide means to block dirty or corrosive system fluid from entering the control unit. The formation of condensate shall not be allowed if it affects the functionality of the control unit.

(-f) shall be designed to provide means for sealing all external adjustments. Seals shall be installed by the manufacturer, or the manufacturer's authorized representative, at the time of the initial adjustment. Seals shall be installed in such a manner as to prevent changing the adjustment without breaking the seal and shall serve as a means of identifying the manufacturer or the manufacturer's authorized representative.

(3) Inspection and testing by manufacturers and assemblers shall comply with PG-73.4, PG-73.5, PG-73.6, PG-73.7, and PG-73.8.

(4) In addition to the marking requirements of PG-110, the main valve marking shall include an identification of the accompanying control unit. The control unit shall be plainly marked by the manufacturer or assembler showing the name of the manufacturer, the manufacturer's design or type number, the set pressure in psi (MPa), an identification of the accompanying main valve(s), and the year built, or alternatively, a coding that the manufacturer can use to identify the year built.

(b) Pressure relief valves for superheater and reheater outlets shall be either direct spring-loaded safety valves, assisted safety valves, supplementary loaded safety valves, or pilot-operated safety valves consisting of a main valve controlled by signals from three pilot valves. Every reheater shall have one or more pressure relief valves with a combined relieving capacity not less than 15% of the required capacity, located along the steam flow path between the reheater outlet and the first stop valve.

Power-actuated pressure-relieving valves may be located at the reheater outlet. Power-actuated pressure-relieving valves discharging directly to atmosphere shall be capacity certified. This capacity certification shall be conducted in accordance with the provision of PG-69.3. The valves shall be marked in accordance with the provi-

sions of PG-69.4. No credit in excess of 30% of the total required relieving capacity shall be allowed for the installed power-actuated pressure-relieving valves.

Any or all of the pressure relief valves may be set above the maximum allowable working pressure of the parts to which they are connected, but the set pressures shall be such that when all of these valves, together with the power-actuated pressure-relieving valves, are in operation the pressure will not rise more than 20% above the maximum allowable working pressure of any part of the boiler.

A direct spring-loaded safety valve is a safety valve using only a spring to oppose the fluid pressure under the valve disc. An assisted safety valve uses a powered assistance mechanism that additionally lifts the valve at a pressure lower than the set pressure and will, even in the event of failure of the assistance mechanism, comply with all the requirements for the safety valve. A supplementary loaded safety valve has, until the pressure at the inlet to the safety valve reaches the set pressure, an additional force to the spring force, which increases the sealing force. The pressure relief valve shall be suitable for the outlet design conditions.

For supplementary loaded safety valves, the supplementary load must be reliably released when the pressure at the inlet of the safety valve reaches the set pressure. If the supplementary loading is not released, the safety valve shall attain its certified discharge capacity at a pressure not greater than 1.1 times the maximum allowable pressure of the equipment to be protected. The set pressure of supplementary loaded safety valves shall not be greater than 10% above the maximum allowable working pressure.

Assisted safety valves and supplementary loaded safety valves are safety valves in combination with a control unit. Multiple safety valves may be controlled by one control unit. The control unit shall comply with the requirements of this Code Case for the control units for turbine bypass valves.

(c) Turbine bypass valves and associated inlet piping installed as overpressure protection for the boiler shall be included as BEP. The discharge connection of the turbine bypass valves is the limit of BEP for these installations.

(d) This Case number shall be shown on the Master Data Report.

Case 3033

Use of Materials from the 2019 Edition

Section IV

Approval Date: November 27, 2021

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the materials listed in Table HF-300.1, HF-300.1M, HF-300.2, HF-300.2M, HLW-300, or HLW-301 of the 2019 edition of Section IV be used for items constructed to the 2021 edition of Section IV?

Reply: It is the opinion of the Committee that materials listed in Table HF-300.1, HF-300.1M, HF-300.2, HF-300.2M, HLW-300, or HLW-301 of the 2019 edition of Section IV may be used for items constructed to the 2021 edition of Section IV, provided the following requirements are met:

(a) This Case applies only for those materials not listed in the 2021 edition of Section II, Part D, Table 6A, 6B, 6C, or 6D, as applicable.

(b) All data from the 2019 edition Section IV, Table HF-300.1, HF-300.1M, HF-300.2, HF-300.2M, HLW-300, or HLW-301, as applicable, shall be used including the allowable stress, temperature limit, external pressure chart assignment, and Notes.

(c) All other material property data shall be from the 2021 edition of Section II, Part D, such as Tables U and Y-1, external pressure charts and tables, and physical properties.

(d) This Case may be used for parts designed by calculation, analysis, or proof test, as permitted by the 2021 edition of Section IV.

(e) All other requirements of the 2021 edition of Section IV shall apply.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3034

Waiver of UW-9(h)(4) Rules

Section VIII, Division 1

Approval Date: December 15, 2021

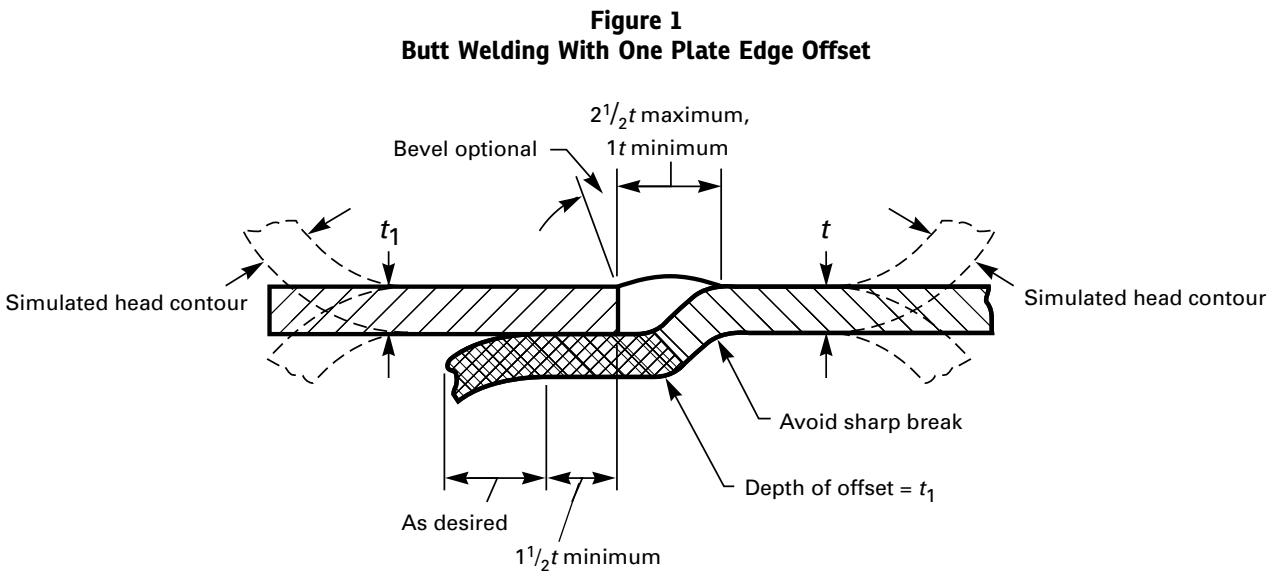
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the requirements of UW-9(h)(4) be waived for offset weld joints attaching dished elliptical or torispherical heads to cylindrical shells as shown in Figure 1 for Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that the requirements of UW-9(h)(4) may be waived for offset weld joints attaching dished elliptical or torispherical heads to cylindrical shells as shown in Figure 1 for Section VIII, Division 1 construction, provided the following requirements are met:

(a) The tangent of the offset joint shall not overlap the tangent of the knuckle radius.

(b) This Case number shall be shown on the Manufacturer's Data Report.



GENERAL NOTE: $1 t$ and $t_1 \leq \frac{5}{8}$ in. (16 mm).

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Case 3035

Minimum Thickness of Standard Fittings Under UW-16(f)(3)(-a)(-6)

Section VIII, Division 1

Approval Date: January 3, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the thickness of standard fittings attached with a single fillet weld under the rules of UW-16(f)(3)(-a) be less than specified by UW-16(f)(3)(-a)(-6) as shown in Figure UW-16.1?

Reply: It is the opinion of the Committee that the thickness of standard fittings attached with a single fillet weld under the rules of UW-16(f)(3)(-a) may be less than speci-

fied by UW-16(f)(3)(-a)(-6) as shown in Figure UW-16.1, provided the following requirements are met:

(a) The thickness of the standard fitting shall not be less than the nominal thickness of an ASME B16.11, Class 3000, threaded coupling as shown in [Table 1](#) or [Table 1M](#). The nominal thickness of an ASME B16.11, Class 3000, socket weld coupling is also acceptable.

(b) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Class 3000 Coupling Nominal Thickness

NPS, in.	Coupling O.D., in.	Pipe O.D., in.	Thickness, in.
$\frac{1}{8}$	0.62	0.405	0.108
$\frac{1}{4}$	0.75	0.540	0.105
$\frac{3}{8}$	0.88	0.675	0.103
$\frac{1}{2}$	1.12	0.840	0.140
$\frac{3}{4}$	1.38	1.050	0.165
1	1.75	1.315	0.218
$1\frac{1}{4}$	2.25	1.660	0.295
$1\frac{1}{2}$	2.5	1.900	0.300
2	3.00	2.375	0.313
$2\frac{1}{2}$	3.62	2.875	0.373
3	4.25	3.50	0.375

Table 1M
Class 3000 Coupling Nominal Thickness

DN, mm	Coupling O.D., mm	Pipe O.D., mm	Thickness, mm
6	16	10.3	2.9
8	19	13.7	2.7
10	22	17.1	2.5
15	28	21.3	3.4
20	35	26.7	4.2
25	44	33.4	5.3
32	57	42.2	7.4
40	64	48.3	7.9
50	76	60.3	7.9
65	92	73.0	9.5
80	108	88.9	9.6

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Case 3036

Alternative Requirements for Certifying Engineer Qualification

Section VIII, Division 1; Section VIII, Division 2

Approval Date: January 6, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: As an alternative to the requirements of Section VIII, Division 1, Mandatory Appendix 47, 47-2(a)(1) or Section VIII, Division 2, Annex 2-J, 2-J.3.2(c), under what conditions may an engineer chartered, registered, or licensed within the jurisdictions where the vessel design and manufacturing take place and the jurisdiction of the location of the installation, be qualified as a Certifying Engineer?

Reply: It is the opinion of the Committee that in lieu of the requirements of Section VIII, Division 1, Mandatory Appendix 47, 47-2(a)(1) or Section VIII, Division 2, Annex 2-J, 2-J.3.2(c), an engineer chartered, registered, or licensed within the jurisdictions where the vessel design and manufacturing take place and the jurisdiction of the location of the installation, shall comply with the following requirements to be qualified as a Certifying Engineer:

(a) The engineer shall have met all qualification requirements given in Section VIII, Division 1, Mandatory Appendix 47, 47-2(a)(2), or Section VIII, Division 2, Annex 2-J, 2-J.3.2(b), except that the engineer shall have a minimum of 8 yr of experience in the design of

pressure vessels and any supplemental requirements stipulated by the user. For Division 2 applications, the engineer shall attest in writing that they understand and meet the requirements of the ASME Code of Ethics.

(b) The engineer shall have received authority to perform engineering work from licensing or registering authorities.

(c) The engineer shall identify the locations and the licensing or registering authorities under which they have received the authority to perform engineering work.

(d) The engineer shall comply with the requirements of the locations to practice engineering where the vessel design and manufacturing take place, and the requirements of location of the installation.

(e) The engineer shall provide evidence showing that engineers in the jurisdictions where the vessel design and manufacturing take place, and the jurisdiction of the location of the installation, are not currently able to be chartered, registered, or licensed in accordance with Section VIII, Division 1, Mandatory Appendix 47, 47-2(a)(1), or Section VIII, Division 2, Annex 2-J, 2-J.3.2(c), to the satisfaction of the Authorized Inspector.

(f) The jurisdictions where the vessel design and manufacturing take place and the jurisdiction of the location of the installation shall be within Central and South America.

(g) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3037-1

Use of 1.15Ni-0.65Cu-Mo-Cb (UNS K21001) High-Strength Low-Alloy Steel Seamless Pipes and Tubes, Flat Products, Forgings, and Fittings

Section VIII, Division 1

Approval Date: June 15, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May high-strength low-alloy steel seamless pipes and tubes, flat products, forgings, and fittings from 1.15Ni-0.65Cu-Mo-Cb with a chemical composition conforming to [Table 1](#), mechanical properties conforming to [Table 2](#) or [Table 2M](#), and otherwise conforming to the specifications listed in [Table 3](#), be used for Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that high-strength low-alloy steel seamless pipes and tubes, flat products, forgings, and fittings from 1.15Ni-0.65Cu-Mo-Cb with a chemical composition conforming to [Table 1](#), mechanical properties conforming to [Table 2](#) or [Table 2M](#), and otherwise conforming to the specifications listed in [Table 3](#), may be used for Section VIII, Division 1 construction, provided the following requirements are met:

(a) For Class 1 the material shall be normalized at 1,650°F (900°C) minimum and tempered at 1,100°F (595°C) minimum but not higher than 1,200°F (650°C). For Class 2 the material may be normalized at 1,650°F (900°C) minimum and tempered at 1,000°F (540°C) minimum but not higher than 1,150°F (620°C) or may be austenitized at 1,650°F (900°C) minimum, quenched, and then tempered at 1,000°F (540°C) minimum but not higher than 1,150°F (620°C). Both heat treatment conditions are allowable for flat products. The minimum tempering time shall be the same as the holding time for postweld heat treatment given in [Table 6](#).

(b) The maximum allowable stress values shall be those given in [Table 4](#) or [Table 4M](#).

(c) The maximum design temperature shall not exceed 700°F (371°C).

(d) Physical properties shall be those listed in [Table 5](#) or [Table 5M](#).

(e) Separate welding procedure and performance qualifications shall be conducted for this material in accordance with Section IX.

(f) Postweld heat treatment is mandatory under all conditions. The postweld heat treatment of the Class 1 and Class 2 materials shall be in accordance with the rules specified in [Table 6](#).

(g) Charpy-V Notch impact test is required and shall be performed at temperature not warmer than the minimum design metal temperature. The minimum energy requirements for Class 1 materials shall be those shown in Figure UG-84.1 (Figure UG-84.1M), and the minimum lateral expansion opposite the notch for Class 2 materials shall not be less than the values shown in Figure UHT-6.1 (Figure UHT-6.1M). In addition, all other applicable requirements of UG-84 shall be fulfilled.

(h) The material shall not exceed a Brinell Hardness Number 250 HBW (HRC 25).

(i) After either cold forming to strains in excess of 5% or any hot forming of this material, the full length of the component shall be heat treated in accordance with the requirements specified in (a). (See Table UG-79-1 of Section VIII, Division 1 for method for calculating strain.)

(j) For external pressure design, Section II, Part D, Figure CS-2 shall be used.

(k) This Case number shall be shown on the marking and certification for the material and on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Chemical Element	Composition Limits, %
Carbon	0.10 – 0.17
Manganese	0.80 – 1.20
Phosphorus, max.	0.025
Sulfur, max.	0.01
Silicon	0.25 – 0.50
Chromium, max.	0.3
Molybdenum	0.25 – 0.50
Nickel	1.00 – 1.30
Columbium/Niobium	0.015 – 0.045
Nitrogen, max.	0.02
Aluminum	0.015 – 0.050
Copper	0.50 – 0.80
Vanadium, max.	0.02

Table 2
Mechanical Properties Requirements

Pipes, Tubes, Forgings, and Fittings				
		Class 1		Class 2
Tensile strength, min., ksi		90		95.5
Yield strength, min., ksi		64		66.5
Elongation in 2 in., min., % [Note (1)], [Note (2)]		15		15
Flat Products				
Product thickness <i>T</i> , in.	$T \leq 1^{5/8}$	$1^{5/8} < T \leq 2^{1/4}$	$2^{1/4} < T \leq 4$	$4 < T \leq 6$
Tensile strength, flat products, ksi	88.5-113	88.5-113	87.0-110	85.5-107
Yield strength, min., ksi	66.5	64.0	62.0	61.0
Elongation in 2 in., min., % [Note (1)], [Note (2)]	16	16	16	16

NOTES:

(1) For longitudinal strip tests of pipes and tubes, a deduction from the basic values of 1.00% for each $1/32$ in. decrease in wall thickness below $5/16$ in. shall be made. The following table gives the computed values:

Wall Thickness, in., as Defined in the Material Specification	Minimum Elongation in 2 in., %
$5/16$	15
$9/32$	14
$1/4$	13
$7/32$	12
$3/16$	11
$5/32$	10
$1/8$	9
$3/32$	8
$1/16$	7
0.062 to 0.035, excl.	7
0.035 to 0.022, excl.	6
0.022 to 0.015, incl.	6

(2) Calculated elongation values shall be rounded to the nearest whole number.

Table 2M
Mechanical Properties Requirements

Pipes, Tubes, Forgings, and Fittings				
		Class 1	Class 2	
Tensile strength, min., MPa		620	660	
Yield strength, min., MPa		440	460	
Elongation in 50.0 mm, min, % [Note (1)], [Note (2)]		15	15	
Flat Products				
Product thickness T , mm	$T \leq 40$	$40 < T \leq 60$	$60 < T \leq 100$	$100 < T \leq 150$
Tensile strength, flat products, MPa	610–780	610–780	600–760	590–740
Yield strength, min., MPa	460	440	430	420
Elongation in 50.0 mm, min., % [Note (1)], [Note (2)]	16	16	16	16

NOTES:

- (1) For longitudinal strip tests of pipes and tubes, a deduction from the basic values of 1.00% for each 0.8 mm decrease in wall thickness below 8.0 mm shall be made. The following table gives the computed values:

Wall Thickness, mm., as Defined in the Material Specification	Minimum Elongation in 50.0 mm, %
8.0	15
7.2	14
6.4	13
5.6	12
4.8	11
4.0	10
3.2	9
2.4	8
1.6	7
1.6 to 0.9, excl.	7
0.9 to 0.6, excl.	6
0.6 to 0.4, incl.	6

- (2) Calculated elongation values shall be rounded to the nearest whole number.

Table 3
Specifications and Grades

Product	Specifications and Grades
Tube	SA-213, T36
Pipe	SA-335, P36
Forgings and fittings	SA-182, F36
Flat product	SA/EN 10028-2, 15NiCuMoNb 5-6-4

**Table 4
Maximum Allowable Stress Values**

Tubes According to SA-213, Pipes According to SA-335, Forgings and Fittings According to SA-182				
For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi			
	Class 1		Class 2	
100	25.7		27.3	
200	25.7		27.3	
300	25.1		26.6	
400	25.1		26.6	
500	25.1		26.6	
600	25.1		26.6	
700	25.1		26.6	

Flat Products According to SA/EN 10028-2				
For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi			
	Product Thickness, <i>T</i> , in.			
	$T \leq 1\frac{5}{8}$	$1\frac{5}{8} < T \leq 2\frac{1}{4}$	$2\frac{1}{4} < T \leq 4$	$4 < T \leq 6$
100	25.3	25.3	24.9	24.4
200	25.3	25.3	24.9	24.4
300	25.1	25.1	24.5	23.9
400	25.1	25.1	24.5	23.9
500	25.1	25.1	24.5	23.9
600	25.1	25.1	24.5	23.9
700	25.1	25.1	24.5	23.9

**Table 4M
Maximum Allowable Stress Values**

Tubes According to SA-213, Pipes According to SA-335, Forgings and Fittings According to SA-182				
For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa			
	Class 1		Class 2	
40	178		188	
100	178		188	
150	173		184	
200	173		184	
250	173		184	
300	173		184	
350	173		184	
400 [Note (1)]	173		184	

Flat Products According to SA/EN 10028-2				
For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa			
	Product Thickness, <i>T</i> , mm			
	$T \leq 38$	$40 < T \leq 60$	$64 < T \leq 100$	$100 < T \leq 150$
40	174	174	171	169
100	174	174	171	169
150	173	173	169	165
200	173	173	169	165
250	173	173	169	165
300	173	173	169	165
350	173	173	169	165
400 [Note (1)]	173	173	169	165

NOTE: (1) The maximum design temperature shall be 371°C. Datum for 400°C is provided for interpolation purposes.

Table 5
Physical Properties

For Metal Temperature Not Exceeding, °F	Modulus of Elasticity <i>E</i> , ×10 ³ ksi	Thermal Expansion, ×10 ⁻⁶ (in./in./°F) [Note (1)]	Poisson's Ratio	Density, lb/in. ³
70	27.8	6.4	0.30	0.280
200	27.1	6.7	0.30	0.280
300	26.7	6.9	0.30	0.280
400	26.2	7.1	0.30	0.280
500	25.7	7.3	0.30	0.280
600	25.1	7.4	0.30	0.280
700	24.6	7.6	0.30	0.280

NOTE: (1) Mean coefficients of thermal expansion are those from 70°F to indicated temperature.

Table 5M
Physical Properties

For Metal Temperature Not Exceeding, °C	Modulus of Elasticity <i>E</i> , ×10 ³ GPa	Thermal Expansion, ×10 ⁻⁶ (mm/mm/°C) [Note (1)]	Poisson's Ratio	Density, kg/m ³
40	191	11.5	0.30	7750
100	187	12.1	0.30	7750
150	184	12.4	0.30	7750
200	181	12.7	0.30	7750
250	178	13.0	0.30	7750
300	174	13.3	0.30	7750
350	171	13.6	0.30	7750
400	167	13.8	0.30	7750

NOTE: (1) Mean coefficients of thermal expansion are those from 20°C to indicated temperature.

Table 6
Requirements for Postweld Heat Treatment (PWHT)

Class	PWHT Temperature, °F (°C)	Holding Time
1	1,100 – 1,200 (595 – 650)	Up to 2 in. (50.0 mm) thickness, 1 hr/in. (25 mm), 15 min minimum Over 2 in. (50.0 mm), add 15 min for each additional in. (25 mm)
2	1,000 – 1,150 (540 – 620)	1 hr/in. (25 mm), ½ hr min.

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Case 3038

18Cr-13Ni-3.7Mo-Nb-N Austenitic Stainless Steel, UNS S31740

Section VIII, Division 1

Approval Date: January 10, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May 18Cr-13Ni-3.7Mo-Nb-N austenitic stainless steel (UNS S31740) forgings, plate, seamless or welded pipe, seamless tube, fittings, and bar meeting the chemical composition and mechanical property requirements shown in Tables 1 and 2, and otherwise conforming to one of the specifications given in Table 3, be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section VIII, Division 1 construction provided the following additional requirements are met:

(a) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UHA for austenitic stainless steels.

(b) For external pressure design use Figure HA-4 in Section II, Part D.

(c) The yield strength and tensile strength values are shown in Tables 4 and 4M.

(d) The maximum allowable stress values for the material shall be those given in Tables 5 and 5M. For welded pipe and fitting products, a joint efficiency factor of 0.85 shall be used.

(e) Maximum design temperature of the material shall be 1,100°F (593°C).

(f) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. Separate welding procedure qualification is required for this material. For performance qualifications, this material shall be considered P-No. 8.

(g) Heat treatment shall be performed at a minimum temperature of 1,900°F (1040°C) followed by rapid cooling in air or water, when the fabrication strain exceeds 15% and the design temperature exceeds 1,000°F (540°C).

(h) The material shall be furnished in the solution annealed condition at a minimum temperature of 1,900°F (1040°C) followed by rapid cooling in air or water.

(i) This Case number shall be shown on the documentation and marking of the material. It shall also be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.005–0.020
Manganese, max.	2.00
Phosphorus, max.	0.045
Sulfur, max.	0.030
Silicon, max.	1.00
Chromium	17.0–19.0
Nickel	11.0–15.0
Molybdenum	3.0–4.5
Niobium	0.20–0.50
Nitrogen	0.06–0.15
Niobium/carbon ratio, min.	15
Iron	Balance

Table 2
Mechanical Property Requirements (Room Temperature)

Mechanical Property	Requirement
Tensile strength, min., ksi (MPa)	75 (515)
Yield strength, 0.2% offset min., ksi (MPa)	30 (205)
Elongation in 2 in. (50 mm), min. %	35

Table 3
Product Specifications

Product	Specification
Forgings	SA-182/SA-182M
Tubes	SA-213/SA-213M
Plates	SA-240/SA-240M
Seamless and welded pipes	SA-312/SA-312M
Fittings	SA-403/SA-403M
Bars	SA-479/SA-479M

Table 4
Yield Strength, S_y , and Tensile Strength, S_u , Values

For Metal Temperature Not Exceeding, °F	Yield Strength Values, S_y , ksi [Note (1)]	Tensile Strength Values, S_u , ksi [Note (2)]
100	29.7	74.7
200	24.5	73.9
300	22.3	69.0
400	20.8	65.7
500	19.8	63.7
600	19.0	62.8
650	18.6	62.6
700	18.2	62.6
750	17.8	62.5
800	17.5	62.4
850	17.2	62.2
900	16.9	61.8
950	16.7	61.1
1,000	16.5	60.1
1,050	16.4	58.7
1,100	16.3	56.8

NOTES:

- (1) See General Note (b) of Table Y-1 in Section II, Part D.
- (2) See General Note (b) of Table U in Section II, Part D.

Table 4M
Yield Strength, S_y , and Tensile Strength, S_u , Values

For Metal Temperature Not Exceeding, °C	Yield Strength Values, S_y , MPa [Note (1)]	Tensile Strength Values, S_u , MPa [Note (2)]
40	205	515
65	180	515
100	167	505
125	159	489
150	153	475
175	148	464
200	144	454
225	141	447
250	138	441
275	135	437
300	132	434
325	130	432
350	127	432
375	125	431
400	123	431
425	121	431
450	119	429
475	117	427
500	116	423
525	114	418
550	113	411
575	113	401
600	112 [Note (3)]	388 [Note (3)]

NOTES:

- (1) See General Note (b) of Table Y-1 in Section II, Part D.
- (2) See General Note (b) of Table U in Section II, Part D.
- (3) These values are provided for interpolation purposes only. The maximum design temperature of this material is as stated in (e).

Table 5
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi
75	19.8, 19.8
100	19.8, 19.8
200	16.3, 19.8 [Note (1)]
300	14.8, 19.7 [Note (1)]
400	13.9, 18.8 [Note (1)]
500	13.2, 17.8 [Note (1)]
600	12.6, 17.1 [Note (1)]
650	12.4, 16.7 [Note (1)]
700	12.1, 16.4 [Note (1)]
750	11.9, 16.0 [Note (1)]
800	11.7, 15.7 [Note (1)]
850	11.5, 15.5 [Note (1)]
900	11.3, 15.2 [Note (1)]
950	11.1, 15.0 [Note (1)]
1,000	11.0, 14.9 [Note (1)]
1,050	10.9, 14.7 [Note (1)]
1,100	10.8, <i>12.8</i> [Note (1)], [Note (2)]

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) Values in italics are obtained from time-dependent properties. See Note T8 of Table 1A of Section II, Part D.

Table 5M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
21	137, 137
40	137, 137
65	120, 137 [Note (1)]
100	111, 137 [Note (1)]
125	106, 137 [Note (1)]
150	102, 136 [Note (1)]
175	98.9, 133 [Note (1)]
200	96.2, 130 [Note (1)]
225	93.9, 127 [Note (1)]
250	91.9, 124 [Note (1)]
275	90.0, 121 [Note (1)]
300	88.2, 119 [Note (1)]
325	86.5, 117 [Note (1)]
350	84.9, 115 [Note (1)]
375	83.4, 113 [Note (1)]
400	81.9, 111 [Note (1)]
425	80.5, 109 [Note (1)]
450	79.2, 107 [Note (1)]
475	78.1, 105 [Note (1)]
500	77.1, 104 [Note (1)]
525	76.3, 103 [Note (1)]
550	75.7, 102 [Note (1)]
575	75.1, 101 [Note (1)]
600	74.6, <i>81.6</i> [Note (1)], [Note (2)], [Note (3)]

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) Values in italics are obtained from time-dependent properties. See Note T8 of Table 1A of Section II, Part D.
- (3) The maximum design temperature is 1,100°F (593°C). The value is provided for interpolation only.

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Case 3039

Article RT-5, Hydrostatic Testing Procedure and Equipment for Class I, Class II, and Class III Pressure Vessels

Section X

Approval Date: March 3, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to use a pressure transducer with a digital display for hydrostatic testing per RT-510 (b), provided all of the requirements of Section X have been satisfied?

Reply: It is the opinion of the Committee that Fabricators of Class I, Class II, and Class III pressure vessels may use a pressure transducer with a digital display, provided the following requirements are satisfied:

(a) The pressure transducer shall have an accuracy of $\pm 0.25\%$ of full scale.

(b) A pressure transducer having a wider range of pressure than specified in RT-510(b) may be used, provided the readings give the same or greater degree of accuracy as obtained with a dial pressure gage that meets the range requirement of 1.5 to 4 times the maximum test pressure.

(c) The pressure transducer shall be calibrated in accordance with RT-510(c).

(d) The Authorized Inspection Agency (AIA) of record shall accept the use of a pressure transducer in place of a pressure gage.

(e) This Case number shall be recorded on the appropriate Fabricator's Data Report Form.

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Case 3040

Use of ASTM A313/A313M-18, UNS S30151 With a Rectangular Cross-Section

Section VIII, Division 3

Approval Date: March 17, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may rectangular wire otherwise conforming to ASTM A313/A313M-18, UNS S30151 be used for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that rectangular wire otherwise conforming to ASTM A313/A313M-18, UNS S30151 may be used for Section VIII, Division 3 construction, provided the following additional requirements are met:

(a) This material may be used only for wire winding in accordance with Article KD-9.

(b) The design temperature shall not exceed 100°F (38°C).

(c) For these wire materials, the wire may be rectangular in cross-section, rather than round. The wire rectangular cross-section shall be 0.035 in. to 0.043 in. (0.9 mm to 1.1 mm) thick and 0.154 in. to 0.161 in. (3.9 mm to 4.1 mm) wide, inclusive.

(d) The minimum yield strength shall be 232 ksi (1600 MPa). The tensile strength requirements for the wire shall be 253 ksi (1748 MPa) minimum and 292 ksi (2015 MPa) maximum. All tests including mechanical property tests shall be performed on the rectangular cross-section.

(e) The optional heat treatment described in ASTM A313/A313M-18, Table 9, Note A shall not be used.

(f) The wire winding shall be protected from contact with water by means of a sealed stainless-steel covering that encloses the entire wire winding assembly.

(g) This Case number shall be shown on the material marking and documentation and on the Manufacturer's Data Report.

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Case 3041

Use of Compound Material to Produce Tubes, Part UIG

Section VIII, Division 1

Approval Date: April 1, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to produce graphite heat exchanger tubes using compound material (compound tubes) as defined in Part UIG, UIG-3?

Reply: It is the opinion of the Committee that graphite pressure vessel tubes may be produced using compound material as defined in Part UIG, UIG-3, provided the following additional requirements are met:

(a) Compound tube material shall meet the following minimum material properties:

(1) Minimum tensile strength at room temperature: 1,500 psi (10.3 MPa)

(2) Minimum tensile strength at maximum design temperature: 900 psi (6.2 MPa)

(3) Minimum compressive strength: 4,500 psi (31 MPa)

(4) Maximum coefficient of permeability: 4.5×10^{-6} in.²/sec (2.9×10^{-3} mm²/sec)

(b) Compound tube material shall meet all other requirements for tube material as shown in Part UIG.

(c) Compound tube material test frequency shall be as follows:

(1) Compressive strength: tested property at time of certified material qualification, for each lot and at minimum, every 3 months.

(2) Tensile strength: tested property at time of certified material qualification, for each lot and at minimum, every 3 months.

(3) Tensile strength at maximum material temperature: only at time of certified material qualification.

(4) Coefficient of thermal expansion: the value shall be determined by tests performed at the time of certified material qualification.

(5) Coefficient of permeability: the value shall be determined by tests performed at the time of certified material qualification.

(6) Modulus of elasticity: the value shall be determined based on 10 test specimens at the time of certified material qualification and be appended to Form CMQ.

(7) Modulus of elasticity at maximum material temperature: the value shall be determined based on 10 test specimens at the time of certified material qualification and be appended to Form CMQ.

(8) All above property values shall be reported on the Certified Material Test Report (CMTR).

(d) Values for modulus of elasticity are not limited to the value indicated in Part UIG, UIG-7 and Part UIG, Non-mandatory Introduction, para. (d).

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3042

Use of ASME B16.5-2020 in Lieu of ASME B16.5-2017

Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3

Approval Date: April 1, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May a Certificate Holder use ASME B16.5-2020, Pipe Flanges and Flanged Fittings NPS $\frac{1}{2}$ Through NPS 24 Metric/Inch Standard, in lieu of ASME B16.5-2017 as required by Section VIII, Division 1, Table U-3; Section VIII, Division 2, Table 1.1; or Section VIII, Division 3, Table KG-141?

Reply: It is the opinion of the Committee that a Certificate Holder may use ASME B16.5-2020 in lieu of ASME B16.5-2017 as required by Section VIII, Division 1, Table U-3; Section VIII, Division 2, Table 1.1; or Section VIII, Division 3, Table KG-141, provided the following requirements are met:

(a) Use of a flange or flanged fitting that relies on and meets the requirements of a B16 Case under ASME B16.5-2020, para. 1.10 is not permitted.

(b) This Case number shall be identified in the documentation and on the Manufacturer's Data Report.

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Case 3043

Use of ASME B16.47-2020 in Lieu of ASME B16.47-2017

Section VIII, Division 1; Section VIII, Division 2

Approval Date: April 1, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May a Certificate Holder use ASME B16.47-2020, Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard, in lieu of ASME B16.47-2017 as required by Section VIII, Division 1, Table U-3 or Section VIII, Division 2, Table 1.1?

Reply: It is the opinion of the Committee that a Certificate Holder may use ASME B16.47-2020 in lieu of ASME B16.47-2017 as required by Section VIII, Division 1, Table U-3 or Section VIII, Division 2, Table 1.1, provided the following requirements are met:

(a) Use of a flange or flanged fitting that relies on and meets the requirements of a Case under ASME B16.47-2020, para. 1.12 is not permitted.

(b) This Case number shall be identified in the documentation and on the Manufacturer's Data Report.

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Case 3044
Preheat of Dissimilar Metal Welds

(25)

Section I

ANNULLED

December 28, 2024

Reason: No longer needed.

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Case 3045

Fillet Welded Staybolts in Locomotive-Type Boilers Not Covered Under Part PL

Section I

Approval Date: April 6, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May locomotive-type boilers [e.g., traction engine boilers, locomotive boilers under 30 in. (750 mm) in outside diameter, miniature live steam boilers] not falling under Part PL use fillet welded staybolts in accordance with PL-30.4?

Reply: It is the opinion of the Committee that locomotive-type boilers [e.g., traction engine boilers, locomotive boilers under 30 in. (750 mm) in outside diameter, miniature live steam boilers] not falling under Part PL, may use fillet welded staybolts in Section I construction, provided the following additional requirements are met:

- (a) The requirements of PL-30.4 are met.
- (b) This Case number shall be referenced on the Manufacturer's Data Report.

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Case 3046

Alternative Pore Evaluation and Acceptance Criteria for Diffusion Welded Material, Mandatory Appendix 42

Section VIII, Division 1

Approval Date: April 26, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may pores on or adjacent to diffusion welds in a diffusion welded procedure and welding operator performance qualification test coupon be evaluated and accepted instead of the requirement of Section IX, QW-185.3?

Reply: It is the opinion of the Committee that pores on or adjacent to diffusion welds may be evaluated and accepted instead of the requirement of Section IX, QW-185.3, provided the following requirements are met:

(a) The materials shall be limited to those listed in Tables UHA-23 and UNF-23.

(b) The surfaces that are to be evaluated microstructurally shall measure 12 mm × 12 mm minimum. The examination length shall be the full length of each bond line on each sample.

(c) The samples under microstructural evaluation shall be free from cracks and show no incomplete bond.

(d) Where any surface exhibits porosity on the bond lines when viewed at 50× to 100× magnification, three bond lines on each sample shall be evaluated at 500× magnification. A minimum of three randomly selected fields shall be evaluated on each bond line. Each field shall include a minimum of 200 μm of the bond line. The pore density along the three bond lines for each sample shall be determined using the following equation:

$$\text{pore density, \%} = \frac{\text{average pore size, } \mu\text{m} \times \text{number of pores in examination length} \times 100}{\text{examination length, } \mu\text{m}}$$

The average pore density for each examined bond line shall not be greater than 26%.

(e) This Case number shall be shown on the Procedure Qualification Record and on Manufacturer's Data Report.

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Case 3047

Use of Carbon Steel Pipe Without Requiring Bend or Pressure Testing

Section VIII, Division 1

Approval Date: June 4, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the requirements for bend testing and pressure testing of SA-53/SA-53M for Type E, Grade A pipe be waived for Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that the requirements for bend testing and pressure testing of SA-53/SA-53M for Type E, Grade A pipe may be waived for Section VIII, Division 1 construction, provided the following additional requirements are met:

(a) This Case only provides an exemption to the SA-53/SA-53M, sections 8 and 10 requirements; all other requirements of SA-53/SA-53M for Type E, Grade A shall be met.

(b) The pipe shall only be used for holding elements of a multibolted cover.

(c) The maximum pipe diameter shall be NPS 2 (DN 50), and the maximum nominal wall thickness shall be 0.154 in. (3.91 mm).

(d) The pipe shall not be bent in fabrication.

(e) The maximum design metal temperature shall be 650°F (343°C).

(f) The minimum design metal temperature (MDMT) shall be no colder than -50°F (-46°C). The material in this Case shall be considered to be P-No. 1 Group No. 1 material for the purpose of impact test exemption per UCS-66(d).

(g) The allowable stress and external pressure chart assignment shall be in accordance with Section II, Part D, Table 1A for SA-53/SA-53M Type E, Grade A. The yield and tensile strengths used for design shall be in accordance with Section II, Part D, Tables U and Y-1 for SA-53/SA-53M Type E, Grade A.

(h) All physical properties shall be those for carbon steels with $C \leq 0.30\%$ in Section II, Part D, Subpart 2.

(i) Welding procedure and performance qualification shall be conducted in accordance with Section IX.

(j) All other requirements of Part UCS shall apply.

(k) This Case number shall be shown on the material marking and documentation and on the Manufacturer's Data Report.

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Case 3048

Design Rules for Creep Strength Enhanced Ferritic (CSEF) Steels Which Are Creep Intolerant for Construction

Section I

Approval Date: May 4, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May creep intolerant CSEF steels be used in elevated temperature service (i.e., the time-dependent stress-controlled regime) for Section I construction?

Reply: It is the opinion of the Committee that creep intolerant CSEF steels for various product forms listed in [Table 1](#) may be used in elevated temperature service (i.e., the time-dependent stress-controlled regime) for Section I construction, provided the following additional requirements are met.

1 DEFINITIONS

creep cavitation damage: a manifestation of creep damage, typically as a high density of individual voids (cavities) formed during an exposure to stress and elevated temperatures in the time-dependent regime. CSEF steels that are susceptible to creep cavitation are vulnerable to local creep damage and cracking in regions of higher stress because of their limited capacity for tertiary creep degradation (i.e., microfissuring and cracking).

creep intolerant CSEF steels: creep cavitation susceptibility is indicated by the limited amount of deformation at the time of creep rupture failure. Such materials will exhibit a reduction of area (RoA) value of <70% for specimens which are creep tested at an applied stress that is <60% of the yield stress at the maximum design metal temperature (Section II, Part D, Subpart 1, Table Y-1).

lambda, λ , parameter for creep intolerant CSEF steels: creep intolerant CSEF steels have high susceptibility to creep cavity formation (intolerant behavior), little creep deformation before rupture and high sensitivity to multiaxial stresses (e.g., trending to notch weakening behavior). The lambda parameter is calculated using the equation in [2, Step 1](#) for characterizing creep tolerant/intolerant behavior of CSEF steels.

2 PROCEDURE FOR DETERMINATION OF CREEP INTOLERANT BEHAVIOR

Step 1. Where creep strain data is available, a creep intolerance parameter, λ , value may be calculated using the following equation:

$$\lambda = \frac{\epsilon_f}{\dot{\epsilon}_{\min} t_r}$$

where

ϵ_f = elongation strain at failure
 $\dot{\epsilon}_{\min}$ = minimum creep rate. When relevant, the steady state (secondary) creep rate $\dot{\epsilon}_{ss}$ can be substituted
 t_r = time to rupture

Step 2. The lambda, λ , parameter shall be calculated from either creep rupture data of the tested heats of material obtained in accordance with Section II, Part D, Mandatory Appendix 5 or from published creep test data for the applicable CSEF steel.

NOTE: It has been demonstrated by creep testing Grade 91 Type 2 CSEF steel does not exhibit creep intolerant behavior and is exempt from this Case.

Step 3. Using the data collected from creep rupture testing, calculate the value of λ using the equation in [Step 1](#). If the value of λ is less than 5, the material shall be classified as creep intolerant material.

NOTE: The lambda, λ , parameter is sensitive to conditions of creep testing.

Step 4. If creep rupture testing was not able to be conducted to determine the value of lambda, λ , in [Step 2](#) or no published creep rupture data exists for the applicable CSEF steel, the material shall be classified as creep intolerant and shall follow the requirements of this Case for elevated temperature design.

Step 5. Materials identified as creep intolerant with a component design temperature in the time dependent regime shall use a reduced allowable stress. This reduced allowable stress value is dependent on geometry using a K factor. The allowable stress value provided in

Section II, Part D, Table 1A, shall be multiplied by a factor, F , defined by the following equation:

$$F = \frac{1}{1 + 0.2(K - 1)}$$

where K is a geometry factor defined in Table 2.

Step 6. Given the theoretical basis for K factors in Table 2, a designer may elect to use design-by-analysis methods to calculate the creep redistributed stationary state stress directly and penalize allowable stress consistent with the proposed Code Case or may use elastic analysis to determine a K factor.

Step 7. The resultant allowable stress multiplier is provided in Table 3.

3 MANUFACTURER'S DATA REPORT

This Case number shall be listed on the Manufacturer's Data Report.

Table 1
ASME Material Specification Product Forms for CSEF Steels

Product Form	ASME Material Specification [Note (1)]
Pipe	SA-335
Forgings	SA-369
Fittings	SA-234
Tube	SA-213
Plate	SA-387
Pipe flanges, fittings, valves and parts	SA-182
Pressure vessel plates	SA-1017
Steel castings, CSEF alloy for elevated temperature	SA-1091

GENERAL NOTE: Creep strength enhanced ferritic (CSEF) steels are a family of ferritic alloys whose high temperature creep strength is enhanced by the creation of a precise condition of microstructure, specifically martensite or bainite, which is stabilized during tempering by controlled precipitation of temper-resistant carbides, carbonitrides, or other stable and/or meta-stable phases.

NOTE: (1) CSEF Steels (e.g., Grade 91, Type 1 and 2, Grade 92, Grade 911 and Grade 122).

Table 2
Geometry Factors

Geometry/Feature	K
Cylindrical welded components under internal pressure	1.0
Longitudinal seam welds	1.5
Dished heads	1.5
Unstayed flat heads and covers	2.5
Openings in shells, headers, and heads (with or without compensation)	2.5
Ligaments	2.5
Supports and attachment lugs	2.0

GENERAL NOTE: Use of the above geometry factors does not reduce the risk of failure from creep intolerant behavior. Implementation of the geometry factors simply increases thickness of the component and reduces the allowable stress to increase creep life.

Table 3
Allowable Stress Multiplier

Geometry/Feature	F
Cylindrical welded components under internal pressure	1.000
Longitudinal seam welds	0.909
Dished heads	0.909
Unstayed flat heads and covers	0.769
Openings in shells, headers, and heads (with or without compensation)	0.769
Ligaments	0.769
Supports and attachment lugs	0.833

Case 3049-1

ASTM A351/A351M-14 Grade HG10MnN (UNS J92604)

Section I

Approval Date: October 4, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May austenitic stainless steel castings conforming to ASTM A351/A351M-14 Grade HG10MnN (UNS J92604) be used in welded and nonwelded construction under Section I?

Reply: It is the opinion of the Committee that austenitic stainless steel castings conforming to ASTM A351/A351M-18 Grade HG10MnN (UNS J92604) may be used in welded and nonwelded construction under Section I, provided the following additional requirements are met:

(a) The physical properties for UNS J92604 are found in Section II, Part D as follows:

(1) Thermal expansion properties shall be taken from Group 3 austenitic stainless steel in Table TE-1.

(2) Thermal conductivity and thermal diffusivity shall be taken from Material Group K in Table TCD.

(3) Elastic moduli shall be taken from Material Group G in Table TM-1.

(4) Poisson's Ratio and density values shall be the same as shown for 300-Series austenitic stainless steels in Table PRD.

(b) The maximum allowable stress values for the material shall be those given in Tables 1 and 1M. The maximum design temperature shall be 1,500°F (816°C). A casting quality factor in accordance with PG-25 shall be applied to these allowable stresses.

(c) The yield strength and tensile strength values for use in design shall be as shown in Tables 2 and 2M.

(d) The chemical composition shall be as shown in Table 3.

(e) The casting shall be inspected in accordance with the requirements of Supplementary Requirement S5 of ASTM A351/A351M-14 (radiographic inspection).

(f) With respect to heat treatment, castings shall be used in the as-cast condition. After weld repair, postweld heat treatment is neither required nor prohibited.

(g) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. Separate welding procedure qualification is required for this mate-

rial. For performance qualifications, this material shall be considered P-No. 8.

(h) Weld repairs to castings shall be made with the following welding process and consumables:

(1) Welding process – SMAW

(-a) Specification SFA-5.11/SFA-5.11M

(-b) AWS Classification ENiCrCoMo-1

(-c) UNS Number W86117

(2) Welding process – GMAW and GTAW

(-a) Specification SFA-5.14/SFA-5.14M

(-b) AWS Classification ERNiCrCoMo-1

(-c) UNS Number N06617

(i) Weld repairs to castings as part of materials manufacture shall be made following welding procedures and by welders qualified in accordance with Section IX. All weld repairs shall be recorded with respect to their location on the casting. Supplementary Requirement S12 of SA-703 shall apply. For weld repairs performed as part of materials manufacture, the documentation shall be included with the Materials Test Report. For weld repairs performed by the Manufacturer, documentation shall be included with the Manufacturer's Data Report.

(j) A manufacturer's test report meeting certification requirements of SA-703 shall be provided.

(k) This Case number shall be shown in the material certification and marking of the material.

(l) This Case number shall be shown on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

This material may be expected to develop embrittlement after exposure at moderately elevated temperatures.

See Section II, Part D, Nonmandatory Appendix A, A-207 and A-208.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi
100	21.7	21.7
200	17.7	21.7 [Note (1)]
300	15.5	20.8 [Note (1)]
400	14.1	19.1 [Note (1)]
500	13.2	17.9 [Note (1)]
600	12.6	17.0 [Note (1)]
650	12.4	16.7 [Note (1)]
700	12.2	16.5 [Note (1)]
750	12.0	16.2 [Note (1)]
800	11.9	16.0 [Note (1)]
850	11.7	15.8 [Note (1)]
900	11.6	15.6 [Note (1)]
950	11.5	15.5 [Note (1)]
1,000	11.3	15.3 [Note (1)]
1,050	11.2	15.2 [Note (1)]
1,100	11.1	15.0 [Note (1)]
1,150	11.1	12.5 [Note (2)]
1,200	10.0 [Note (2)]	10.0 [Note (2)]
1,250	7.82 [Note (2)]	7.82 [Note (2)]
1,300	6.01 [Note (2)]	6.01 [Note (2)]
1,350	4.51 [Note (2)]	4.51 [Note (2)]
1,400	3.26 [Note (2)]	3.26 [Note (2)]
1,450	2.24 [Note (2)]	2.24 [Note (2)]
1,500	1.41 [Note (2)]	1.41 [Note (2)]

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for applications where slight amounts of distortion can cause leakage or malfunction.
- (2) Values are time-dependent.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa
40	150	150
65	132	150 [Note (1)]
100	120	150 [Note (1)]
150	107	143 [Note (1)]
200	98.2	133 [Note (1)]
250	92.2	124 [Note (1)]
300	88.0	119 [Note (1)]
325	86.4	117 [Note (1)]
350	85.1	115 [Note (1)]
375	83.9	113 [Note (1)]
400	82.8	112 [Note (1)]
425	81.9	111 [Note (1)]
450	81.0	109 [Note (1)]
475	80.1	108 [Note (1)]
500	79.4	107 [Note (1)]
525	78.6	106 [Note (1)]
550	77.9	105 [Note (1)]
575	77.3	104 [Note (1)]
600	77.2	102 [Note (2)]
625	76.2	83.6 [Note (2)]
650	68.1 [Note (2)]	68.1 [Note (2)]
675	54.7 [Note (2)]	54.7 [Note (2)]
700	43.3 [Note (2)]	43.3 [Note (2)]
725	33.6 [Note (2)]	33.6 [Note (2)]
750	25.4 [Note (2)]	25.4 [Note (2)]
775	18.5 [Note (2)]	18.5 [Note (2)]
800	12.8 [Note (2)]	12.8 [Note (2)]
825	8.00 [Note (3)]	8.00 [Note (3)]

NOTES:

- (1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. These higher stress values exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for applications where slight amounts of distortion can cause leakage or malfunction.
- (2) Values are time-dependent.
- (3) These values are provided at 825°C for interpolation use only. The maximum use temperature is 816°C.

Table 2
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi [Note (1)]	Tensile Strength, ksi [Note (2)]
100	33.0	76.0
200	26.5	76.0
300	23.3	72.8
400	21.2	69.2
500	19.8	66.9
600	18.9	65.7
650	18.6	65.4
700	18.3	65.3
750	18.0	65.1
800	17.8	64.9
850	17.6	64.6
900	17.4	64.2
950	17.2	63.4
1,000	17.0	62.4
1,050	16.9	61.0
1,100	16.7	59.3
1,150	16.6	57.2
1,200	16.5	54.8
1,250	16.4	52.1
1,300	16.4	49.2
1,350	16.4	46.3
1,400	16.4	43.5
1,450	16.4	41.0
1,500	16.4	39.1

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, General Note (b) applies to these values.
(2) Section II, Part D, Subpart 1, Table U, General Note (b) applies to these values.

Table 2M
Yield and Tensile Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa [Note (1)]	Tensile Strength, MPa [Note (2)]
40	228	524
65	198	524
100	180	524
125	169	515
150	160	501
175	153	489
200	147	479
225	142	470
250	138	464
275	135	459
300	132	455
325	130	453
350	128	451
375	126	450
400	124	449
425	123	448
450	122	446
475	120	443
500	119	439
525	118	434
550	117	426
575	116	417
600	115	405
625	114	392
650	114	377
675	113	360
700	113	342
725	113	325
750	113	307
775	113	290
800	113	277
825	113	266
850	113	262

NOTES:

- (1) Section II, Part D, Subpart 1, Table Y-1, General Note (b) applies to these values.
(2) Section II, Part D, Subpart 1, Table U, General Note (b) applies to these values.

Table 3
Chemical Composition for UNS J92604

Element	Composition Limit, %
Chromium	18.5-20.5
Nickel	11.5-13.5
Manganese	3.0-5.0
Niobium	$8 \times C$ min. - 1.0 max.
Silicon	0.70 max.
Molybdenum	0.25-0.45
Nitrogen	0.20-0.30
Copper	0.50 max.
Carbon	0.07-0.11
Phosphorus	0.040 max.
Sulfur	0.030 max.
Iron	Balance

Case 3050

Use of EN 10083-3:2006, Steel Name 34CrMo4+QT (Steel Number 1.7220+QT)

Section VIII, Division 3

Approval Date: July 12, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May quenched and tempered alloy steel, manufactured in accordance with EN 10083-3:2006, Steel Name 34CrMo4+QT (Steel Number 1.7220+QT), be used for construction of forged seamless pressure vessel cylinders with integral head conforming to Section VIII, Division 3?

Reply: It is the opinion of the Committee that quenched and tempered alloy steel, manufactured in accordance with EN 10083-3:2006, Steel Name 34CrMo4+QT (Steel Number 1.7220+QT) may be used in the construction of forged seamless pressure vessel cylinders with integral head conforming to Section VIII, Division 3, provided the following additional requirements are met:

(a) The design temperature shall not exceed 100°F (38°C).

(b) The maximum weight of a cylinder shall be 1,000 lb (450 kg).

(c) Maximum sulfur content shall be 0.025% by mass.

(d) Maximum phosphorus content shall be 0.025% by mass.

(e) Mechanical property tests and their acceptance criteria shall be in accordance with Article KM-2 and the following:

(1) Minimum yield strength: 130,500 psi (900 MPa)

(2) Minimum tensile strength: 153,700 psi (1 060 MPa)

(3) Maximum tensile strength: 178,400 psi (1 230 MPa)

(4) Minimum elongation: 14%

(f) Mechanical property tests shall include one tensile test and one set of three Charpy tests for each heat treatment batch of no more than 200 cylinders or representing no more than 200 cylinders when heat treated in a continuous furnace. The set of 200 cylinders must all be from the same heat of material and be of vessels of identical dimensions.

(g) *Bending Properties.* Depending upon the outside diameter, D , and the wall thickness, T , of hollow or bored forgings, a bend test or flattening test will be required.

(1) For forgings with outside diameters of 14 in. (355 mm) or less and with a D/T ratio of more than 10.0, a flattening test is required. This shall be carried out in accordance with SA-530/SA-530M and with the distance between the plates to be $0.9D$ min. No breaks or cracks in the test ring are acceptable until the distance between the plates is less than $0.9D$.

(2) For bored or hollow forgings with outside diameters over 14 in. (355 mm), or where the D/T ratio is 10.0 or less at the manufacturer's option, the flattening test specified in (1), or a transverse bend test in accordance with Arrangement C of Test Method ASTM E290 is required. The bend test pin diameter shall be $6T$. No cracks or ruptures in the test piece are allowable when the test piece is bent through an angle of 150 deg.

(h) *Hardness Testing*

(1) Forgings under 1,000 lb (450 kg) in weight, heat treated in a batch lot of up to 200 pieces or in a continuous furnace run covering up to 200 pieces in up to 4 hr production shall be subject to a uniformity check by Brinell hardness testing, or an equivalent method. For this purpose, a hardness test shall be performed on the forging from which the tensile test is taken, and 10% of the furnace production shall be sampled and shall be within 20 Brinell points of the hardness of the forging from which the tensile test was taken.

(2) In the event that the test sample does not meet this criterion, the remainder of that production group shall be hardness tested, and all of those forgings that fall outside the limit specified in (1) shall be retempered or reheat-treated at the manufacturer's option and retested.

(i) Modulus of elasticity used in design shall be from Section II, Part D, Table TM-1, Group C.

(j) The coefficient of thermal expansion used in design shall be from Section II, Part D, Subpart 2, Table TE-1, Group 1.

(k) The coefficients of thermal conductivity and thermal diffusivity used in design shall be from Section II, Part D, Subpart 2, Table TCD, Group C.

(l) The density and Poisson's ratio used in design shall be from Section II, Part D, Subpart 2, Table PRD for low alloy steels with $\frac{1}{2}$ Cr to $1\frac{1}{4}$ Cr steels.

(m) For external pressure design, Section II, Part D, Figure HT-1 shall be used.

(n) The minimum yield and minimum tensile strength values used in design shall be as specified in (e) for use not exceeding 100°F (38°C).

(o) The material shall be delivered with specific inspection and testing in accordance with an inspection certificate of EN 10204, in addition to the requirements of Section VIII, Division 3.

(p) No welding is permitted on this material.

(q) *Marking.* Each forging shall be legibly identified as required by the product specification and instructions from the purchaser. When not otherwise defined, each forging shall be identified by the manufacturer as follows:

(1) Manufacturer's name or symbol

(2) Manufacturer's identification or heat number

(3) Product specification number

(4) Class, grade, and type identification as appropriate

(5) Purchaser's identification

(r) See Section II, Part A, Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10083-3:2006 and its references for use in conjunction with this Case.

(s) This Case number shall be shown on the material certification as required in (o), marking on the material, and on the Manufacturer's Data Report.

Case 3051

Alternative Rules for Access and Inspection of a Water Boiler 60 in. (1500 mm) or Over in Diameter

Section IV

Approval Date: August 22, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the manhole requirements, per HG-330.2, for a water boiler 60 in. (1500 mm) or over in diameter be eliminated when space restrictions would prohibit entry to the boiler?

Reply: It is the opinion of the Committee that manhole requirements, per HG-330.2, for a water boiler 60 in. (1500 mm) or over in diameter may be eliminated

when space restrictions would prohibit entry to the boiler, provided the following requirements are met:

(a) Sufficient inspection openings, handholes, or washout plugs shall be included to ensure adequate inspection and flushing of loose scale and sediment of the waterside components.

(b) The remaining requirements of HG-330 concerning inspection and access openings shall continue to be met.

(c) All other requirements of Section IV shall apply.

(d) This Case number shall be shown on the Master Data Report.

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Case 3052

Use of EN 10216-3:2013, Grade P690QL2, Fine-Grain Seamless Steel Tubes; and EN 10028-6:2017, Grade P690QL2 Fine-Grain Flat Products

Section VIII, Division 1; Section VIII, Division 2

Approval Date: August 29, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May EN 10216-3:2013, Grade P690QL2 fine-grain seamless steel tubes; and EN 10028-6:2017, Grade P690QL2 fine-grain flat products be used in Section VIII, Division 1 construction; and Section VIII, Division 2 construction?

Reply: It is the opinion of the Committee that fine-grain seamless steel tubes, manufactured in accordance with EN 10216-3:2013, Grade P690QL2; and fine-grain flat products manufactured in accordance with EN 10028-6:2017, Grade P690QL2 may be used in Section VIII, Division 1 and Section VIII, Division 2 construction, provided the following additional requirements are met:

- (a) The thickness shall not exceed the following:
 - (1) for seamless steel tubes: $1\frac{9}{16}$ in. (40 mm)
 - (2) for fine-grain flat products: 2 in. (50 mm)
- (b) The maximum design temperature shall not exceed 200°F (93°C)
- (c) The minimum design metal temperature shall not be colder than -40°F (-40°C)
- (d) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. This material shall be considered P-No. 11B, Group 4.
- (e) Postweld heat treatment is neither required nor prohibited. Consideration should be given to the possibility of temper embrittlement. The cooling rate from PWHT, when used, shall not be slower than that obtained by cooling in still air. When required, PWHT shall be performed at 1,000°F to 1,150°F (540°C to 620°C), holding 1 hr/in. (0.04 h/mm) for a minimum of 1 hr.
- (f) The following additional requirements for testing shall apply:
 - (1) *Tension Tests.* For quenched and tempered plates one tension test shall be taken from each end of the heat-treated plate. The gage length of the tension test specimens shall be taken at least $1T$ from any heat-treated edge, where T is the thickness of the plate, and shall

be at least $\frac{1}{2}$ in. (12.5 mm) from flame cut or heat-affected-zone surfaces.

(2) *Impact Test Sampling.* Deviation from the requirement for preparation of test pieces for impact testing in EN 10028-1 shall not be permitted.

(g) The maximum allowable stress values for this material shall be limited to the following:

(1) for Section VIII, Division 1 design: 31.9 ksi (220 MPa)

(2) for Section VIII, Division 2, Class 1 design: 37.2 ksi (257 MPa)

(3) for Section VIII, Division 2, Class 2 design: 46.5 ksi (321 MPa)

(h) Physical properties shall be as follows:

(1) Density: 0.280 lb/in.³ (7750 kg/m³).

(2) Thermal expansion as shown in Section II, Part D, Table TE-1 for carbon and low alloy steels, Group 1.

(3) Thermal conductivity and diffusivity as shown in Section II, Part D, Table TCD for carbon and low alloy steels, Group B.

(4) Elastic moduli as shown in Section II, Part D, Table TM-1 for carbon steels with $C \leq 0.30\%$.

(i) For external pressure design, the requirements of Section II, Part D, Figure CS-5 shall apply.

(j) All other Section VIII design requirements shall apply. This material is a Q&T steel with enhanced tensile properties and therefore:

(1) For Section VIII, Division 1 design, all applicable requirements of Part UHT shall apply.

(-a) For EN 10028-6:2017, Grade P690QL2 plates with thickness above 1 in. (25.4 mm) and MDMT lower colder than -20°F (-29°C), in addition to the impact tests in accordance with UHT-6(a), drop weight tests as defined by ASTM E208 shall be performed. One drop weight test (two specimens) shall be made for each plate as heat treated; each of the two specimens shall meet the "no break" criterion, as defined by ASTM E208, at test temperature no warmer than MDMT.

(2) For Section VIII, Division 2 design, all applicable requirements from paras. 3.5, 3.11.3, and 6.6 shall apply.

(3) For fatigue design according to Section VIII, Division 2, Annex 3-F, the requirements for carbon, low alloy, series 4XX, high alloy, and high tensile strength steels shall apply.

(k) This Case number shall be shown in the documentation and marking of the material and on the Manufacturer's Data Report.

Case 3053

Use of Taper Pipe Threads

(25)

Section VIII, Division 3

Approval Date: August 30, 2022

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may taper pipe threads be used in Section VIII, Division 3 construction in lieu of KD-620(b)?

Reply: It is the opinion of the Committee that taper pipe threads may be used in Section VIII, Division 3 construction in lieu of KD-620(b), provided the following requirements are met:

(a) Taper threads shall be used in nozzle necks on the inside surface only.

(b) Thread types shall be National Gas Taper (NGT) in accordance with CGA V-1-2021 or ISO 11363-1-2018 standard.

(c) Nominal threads size shall not exceed 1.0 in. NGT per CGA V-1-2021 or 25E per ISO 11363-1-2018 standard.

(d) Design pressure shall not exceed 6,000 psi (41 MPa). Maximum design temperature shall not exceed 200°F (93°C).

(e) All applicable requirements of Article KD-6 shall be met. Additionally, an elastic-plastic finite element analysis (FEA) of the connection shall be performed in accordance with KD-230 through KD-236 considering the loads due to the specified assembly torque and all other load cases in Table KD-230.1.

(f) Seal welding of the threads is not permitted.

(g) This Case number shall be listed in the Manufacturer's Design Report and Manufacturer's Data Report.

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Case 3054

Impact Test Requirements of Part UHA Materials Joined by Diffusion Welding

Section VIII, Division 1

Approval Date: September 6, 2022

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may diffusion welding be used to join Part UHA materials when the minimum design metal temperature is colder than -320°F (-196°C)?

Reply: It is the opinion of the Committee that diffusion welding may be used to join Part UHA materials when the minimum design temperature is colder than -320°F (-196°C), provided the following requirements are met:

(a) Welding procedure qualification shall include impact test of welds.

(b) Two sets of three impact test specimens in accordance with UG-84(c) shall be taken from the test block for procedure qualification described in QW-185. One set is perpendicular to the interface planes, and the other is parallel to the interface planes.

(c) Impact test shall be performed at -320°F (-196°C), and each of three specimens from each test set shall have a lateral expansion opposite the notch no less than 0.021 in. (0.53 mm).

(d) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3055

RT-310(a), Frequency of Cyclic Pressure and Qualification Pressure Tests

Section X

Approval Date: August 5, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to extend qualification to 1 yr when more than 1,000 duplicate stamped Section X, Class I pressure vessels are produced, as required by RT-310(a), provided all of the requirements of Section X have been satisfied?

Reply: It is the opinion of the Committee that Fabricators of Class I pressure vessels may extend qualification to 1 yr when more than 1,000 duplicate stamped vessels are produced, as required by RT-310(a), provided the following requirements are met:

(a) The Fabricator shall have at least 3 yr of experience manufacturing mass-produced duplicate ASME certified pressure vessels.

(b) The Authorized Inspection Agency (AIA) of record shall accept the qualification extension. The AIA shall have at least 3 yr of established history providing inspections at the Fabricator's location.

(c) No other material or process changes of the essential variables shall be permitted from the original qualification vessel when manufacturing the duplicate vessels.

(d) This Case shall only apply to the fabrication method of filament-winding process, Class I pressure vessels.

(e) This Case shall only apply to Fabricators of multiple duplicate vessels in accordance with RI-160.

(f) This Case number shall be recorded on the appropriate Form RP-1, Fabricator's Data Report for Fiber-Reinforced Plastic Pressure Vessels (Class I).

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Case 3056

Ni-25Cr-20Co Material, UNS N07740

Section VIII, Division 1

Approval Date: September 6, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May precipitation-hardenable Ni-25Cr-20Co alloy (UNS N07740) seamless alloy pipe and tube; plate, sheet and strip; welded tube; bars, forgings, and forging stock; and fittings material conforming to the chemical requirements shown in [Table 1](#), the mechanical properties listed in [Table 3](#), and otherwise conforming to the applicable requirements in the specifications listed in [Table 4](#) be used in welded and nonwelded construction under Section VIII, Division 1 rules?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in welded and nonwelded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met:

- (a) The various forms for this alloy shall conform to the specifications listed in [Table 4](#).
- (b) The chemical composition of this alloy shall conform to [Table 1](#).
- (c) The maximum design temperature is 1,472°F (800°C).
- (d) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for nickel, cobalt and high-nickel alloys.
- (e) For all product forms listed in [Table 4](#), the solution heat treatment shall be performed at 2,010°F (1100°C) minimum for 0.5 hr per 1 in. (25 mm) of thickness but not less than 5 min. The material shall be water quenched or rapid air cooled. Aging shall be performed at 1,400°F to 1,500°F (760°C to 815°C) for 4 hr minimum up to 2 in. (50 mm) of thickness, plus an additional 0.5 hr per additional 1 in. (25 mm) of thickness. Aging shall be followed by air cooling.
- (f) As an alternative to the delivery conditions of (e), where the material is to be subjected to additional fabrication operations, the material may be supplied in the solution annealed condition provided the following:

(1) The marking shall include the suffix "Y" immediately following the Specification number and preceding any other suffix. The "Y" suffix shall not be removed

until the material specification requirements have been completed and the material test report supplemented.

(2) Material supplied in the solution annealed condition shall meet 105 ksi (724 MPa) minimum tensile strength, 60 ksi (414 MPa) minimum yield strength and 30% minimum elongation in 2 in. (50 mm) or 4D (refers to diameter of the tensile specimen) min.

(3) The material supplier shall carry out the full heat treatment requirements of (e) on a sample from the delivery lot to demonstrate compliance with the delivery conditions of this Case.

(4) On completion of all fabrication operations, the entire component shall be heat treated in accordance with the requirements of (e) to obtain the mechanical properties in [Table 3](#). Local solution annealing is not permitted.

(g) The maximum allowable stress values for the material shall be those given in [Tables 5](#) and [5M](#).

(h) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. Separate welding procedure qualification is required for this material. For performance qualifications, this material shall be considered P-No. 46. Weld procedure qualifications shall be performed with material in the heat-treated condition that is planned for production welding. This may either be the condition stipulated in (e) or alternately as noted in (f). If welding of both heat treat conditions is planned, both qualifications shall be required. The heat-treated condition shall be noted on the PQR and WPS. When welding this alloy to itself, the filler metal shall be SFA-5.14 ERNiCrCo-1 (UNS N07740). Welding shall be limited to solid bare-wire filler metal or electrodes using either the GTAW or GMAW processes, respectively. The welding procedure qualification(s) shall be conducted as prescribed in Section IX except that the guided bend test required by QW-160 shall use a 4t maximum bend radius.

(i) As an alternative to welding this material with a matching filler metal as noted in (h), SMAW electrodes whose deposit meets the compositional requirements shown in [Table 2](#) may be used. The welding procedure qualifications shall be conducted as prescribed in ASME Section IX except that the guided bend test required by QW-160 shall use a 4t maximum bend radius.

(j) Postweld heat treatment for this material is mandatory. The postweld heat treatment shall be performed at 1,400°F to 1,500°F (760°C to 815°C) for a minimum of 4 hr

for thickness up to 2 in. (50 mm), plus an additional 1 hr per additional 1 in. (25 mm) of thickness and air-cooled.

(k) When using UNS N07740 with matching weld metal composition, all longitudinal weld seams required in the construction of a component must have applied to it a weld strength reduction factor of 0.70 for applications at temperatures above 1,112°F (600°C). When using SMAW electrodes meeting the compositional requirements of Table 2 for making longitudinal weld seams, the weld strength reduction factors at their corresponding temperature shall be those listed in Table 6.

(l) Impact testing is required when minimum design metal temperature (MDMT) is colder than 70°F (20°C). Impact testing of base metal, weld metal, and heat affected zone shall be conducted using the rules of UG-84. The minimum lateral expansion of each specimen shall be no less than 0.015 in. (0.38 mm) and the test temperature shall be no warmer than the specified MDMT.

(m) Resistance welding may be used to join non-load bearing attachments to precipitation-hardenable Ni-25Cr-20Co alloy (UNS N07740) ASTM B983-16 seamless alloy pipe and tube and ASTM B1007-17 welded tube materials. Postweld heat treatment in accordance with (j) is not mandatory for electric resistance welds used to attach extended heat-absorbing fins or other nonload bearing attachments to pipe and tube materials, provided the following requirements are met:

(1) The maximum pipe or tube size shall be NPS 4 (DN 100).

(2) The maximum fin thickness or other non-load bearing attachments shall be 0.125 in. (3 mm). Fins or other nonload bearing attachments can be of any austenitic stainless steel.

(3) Prior to using the welding process, the manufacturer shall demonstrate that the heat-affected zone does not encroach upon the minimum wall thickness.

(n) The requirements for post-forming heat treatment shall be as required by UNF-79 except as modified below. After cold forming to strains in excess of 5%; after any swages, upsets, or flares; or after any hot forming of this material, the component shall be heat treated in accordance with the requirements specified in (e). Local aging heat treatment is not permitted. The entire affected component or part that includes the cold-strained area and transition to unstrained material must be included in both aging and solution annealing treatments. The calculations of forming strains shall be determined by the equations in Table UG-79-1.

(o) S_u and S_y values are listed in Tables 7 and 7M and Tables 8 and 8M.

(p) Physical Properties. Density is listed below. Other physical properties are listed in Tables 9 and 9M.

(1) Density: 0.291 lb/in.³ (8072 kg/m³)

(q) External pressure design is prohibited.

(r) For ASTM B983-16, ASTM B872-19, ASTM B1007-17, and ASTM B637-18 material, this Case number shall appear on the Manufacturer's Data Report. For ASTM B366-20, this Case number shall appear in the marking and certification for the material and on the Manufacturer's Data Report. For the postweld heat treatment exemption listed in (m), this Case number shall be shown on the Manufacturer's Data Report or Manufacturer's Partial Data Report for the welded component.

Table 1
Chemical Requirements, UNS N07740

Element	Composition Limits, %
Chromium	23.5–25.5
Cobalt	15.0–22.0
Aluminum	0.2–2.0
Titanium	0.5–2.5
Columbium + Tantalum	0.50–2.5
Iron	3.0 max.
Carbon	0.005–0.08
Manganese	1.0 max.
Molybdenum	2.0 max.
Silicon	1.0 max.
Copper	0.50 max.
Phosphorus	0.03 max.
Sulfur	0.03 max.
Boron	0.0006–0.006
Nickel	Remainder

Table 2
Chemical Requirements, SMAW Electrode

Element	Weight, %
Carbon	0.04–0.08
Silicon	0.4 max.
Manganese	0.6 max.
Aluminum	0.6 max.
Cobalt	19.0–21.0
Chromium	19.0–21.0
Iron	0.7 max.
Molybdenum	5.6–6.1
Titanium	1.9–2.4
Aluminum + Titanium	2.4–2.8
Nickel	Remainder

Table 3
Mechanical Properties Requirements

Tensile strength, min., ksi (MPa)	150 (1 035)
Yield strength, min., ksi (MPa)	90 (620)
Elongation in 2 in. (50 mm), min., %	20

Table 4
Specifications

Material	Specification
Bars, forgings, and forging stock	ASTM B637-21
Plate, sheet, and strip	ASTM B872-19
Seamless alloy pipe and tube	ASTM B983-21
Welded tube	ASTM B1007-21
Wrought fittings	ASTM B366-20

Table 5
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
100	42.9
200	42.9
300	42.9
400	42.6
500	41.1
600	40.3
650	40.1
700	40.0
750	40.0
800	40.0
850	40.0
900	40.0
950	40.0
1,000	40.0
1,050	40.0
1,100	39.8
1,150	39.1
1,200	33.1 [Note (2)]
1,250	26.2 [Note (2)]
1,300	20.2 [Note (2)]
1,350	15.1 [Note (2)]
1,400	10.7 [Note (2)]
1,450	6.9 [Note (2)]
1,500	3.2 [Note (2)], [Note (3)]

NOTES:

- (1) A weld efficiency factor of 0.85 must be applied to welded tube of ASTM B1007 and welded fittings of SB-366.
- (2) These stress values are obtained from time-dependent properties.
- (3) The maximum use temperature shall be 1,472°F. Datum for 1,500°F temperature is provided for interpolation purposes.

Table 5M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
40	295
65	295
100	295
150	295
200	294
250	285
300	279
325	277
350	276
375	276
400	276
425	276
450	276
475	276
500	276
525	276
550	276
575	276
600	274
625	269
650	226 [Note (2)]
675	183 [Note (2)]
700	146 [Note (2)]
725	113 [Note (2)]
750	84.1 [Note (2)]
775	59.1 [Note (2)]
800	34.5 [Note (2)]

NOTES:

- (1) A weld efficiency factor of 0.85 must be applied to welded tube of ASTM B1007 and welded fittings of SB-366.
- (2) These stress values are obtained from time-dependent properties.

Table 6
Weld Strength Reduction Factors for Welds Made With the SMAW Electrode Whose Deposit Composition Is Specified in Table 2

For Metal Temperatures Not Exceeding, °F	For Metal Temperatures Not Exceeding, °C	WSRF
1,100	593	0.8
1,150	621	0.8
1,200	649	0.8
1,250	677	0.7
1,300	732	0.7
1,400	760	0.6
1,450	788	0.5
1,500 [Note (1)]	816 [Note (2)]	0.4

NOTES:

- (1) The maximum use temperature is 1,472°F. 1,500°F is provided for interpolation only.
- (2) The maximum use temperature is 800°C. 816°C is provided for interpolation only.

Table 7
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °F	S_u Values, ksi [Note (1)]
100	150
200	150
300	150
400	149
500	144
600	141
650	140
700	140
750	140
800	140
850	140
900	140
950	140
1,000	140
1,050	140
1,100	139
1,150	137
1,200	134
1,250	129
1,300	124
1,350	117
1,400	109
1,450	99.1
1,500	88.2 [Note (2)]

NOTES:

- (1) See General Note (b) of Table U in Section II, Part D.
(2) The maximum use temperature shall be 1,472°F. Datum for 1,500°F temperature is provided for interpolation purposes.

Table 7M
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °C	S_u Values, MPa [Note (1)]
40	1034
65	1034
100	1034
150	1034
200	1030
250	998
300	976
325	970
350	967
375	966
400	966
425	966
450	966
475	966
500	966
525	966
550	966
575	966
600	957
625	942
650	921
675	894
700	860
725	819
750	771
775	715
800	651

NOTE: (1) See General Note (b) of Table U in Section II, Part D.

Table 8
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °F	S_y Values, ksi [Note (1)]
100	90.0
200	86.5
300	83.8
400	81.2
500	79.1
600	77.6
650	77.2
700	76.8
750	76.7
800	76.7
850	76.7
900	76.7
950	76.7
1,000	76.7
1,050	76.7
1,100	76.7
1,150	76.7
1,200	76.7
1,250	76.7
1,300	76.7
1,350	75.3
1,400	72.7
1,450	69.2
1,500	64.5 [Note (2)]

NOTES:

- (1) See General Note (b) of Table U in Section II, Part D.
- (2) The maximum use temperature shall be 1,472°F. Datum for 1,500°F temperature is provided for interpolation purposes.

Table 8M
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °C	S_y Values, MPa [Note (1)]
40	621
65	606
100	594
150	577
200	562
250	548
300	538
325	534
350	531
375	530
400	529
425	529
450	529
475	529
500	529
525	529
550	529
575	529
600	529
625	529
650	529
675	529
700	529
725	522
750	508
775	489
800	463

NOTE: (1) See General Note (b) of Table U in Section II, Part D.

Table 9
Physical Properties

Temperature, °F	Modulus of Elasticity, 10 ³ ksi [Note (1)]	Thermal Conductivity, Btu/ft-hr-°F	Mean CTE, 10 ⁻⁶ in./in./°F [Note (2)]	Specific Heat Btu/lb-°F
68	31.99	6.1	...	0.108
200	31.58	6.7	6.84	0.112
400	30.85	7.6	7.25	0.117
600	29.83	8.5	7.53	0.119
800	28.68	9.4	7.80	0.120
1,000	27.67	10.4	7.96	0.121
1,200	26.37	11.4	8.24	0.126
1,400	25.08	12.4	8.61	0.133
1,600	23.43	13.5	8.88	0.143
1,800	...	14.6	...	0.152
2,000	...	15.8	...	0.155
2,100	...	16.4	...	0.152

NOTES:

(1) Aged at 1,472°F/4 hr/AC.

(2) Mean CTE (coefficient of thermal expansion) values are those from 68°F to indicated temperature.

Table 9M
Physical Properties

Temperature, °C	Modulus of Elasticity, 10 ³ MPa [Note (1)]	Thermal Conductivity, W/(m-°C)	Mean CTE, 10 ⁻⁶ mm/mm/°C [Note (2)]	Specific Heat, J/ kg-°C
20	221	10.2	...	449
100	218	11.7	12.38	476
200	212	13.0	13.04	489
300	206	14.5	13.50	496
400	200	15.7	13.93	503
500	193	17.1	14.27	513
600	186	18.4	14.57	519
700	178	20.2	15.03	542
800	169	22.1	15.72	573
900	...	23.8	...	635
1000	...	25.4	...	656
1100	...	27.3	...	669

NOTES:

(1) Aged at 800°C/4 h/AC.

(2) Mean CTE (coefficient of thermal expansion) values are those from 20°C to indicated temperature.

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Case 3057

Alternative Set Pressure Testing of Pilot-Operated Pressure Relief Valves

Section VIII, Division 1; Section VIII, Division 2; Section X; Section XIII

Approval Date: September 16, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Section XIII, 3.6.3.1(a) requires that each valve be tested to demonstrate its set pressure. In lieu of testing a fully assembled pilot-operated pressure relief valve (POPRV), under what conditions may the pilot be tested separately to demonstrate the POPRV's set pressure?

Reply: It is the opinion of the Committee that in lieu of demonstrating the set pressure of a fully assembled POPRV per 3.6.3.1(a), the set pressure may be demonstrated by testing the pilot separately, provided the following requirements are met:

(a) The pilot shall meet the set pressure requirements of 3.6.3.1(b) through (e).

(b) The fully assembled valve shall then be tested to verify that all components are properly connected, leak tight, and the pilot actuates the main valve. For liquid or steam service, this test may be conducted on air or other suitable gas.

(c) This Case number shall be shown on the Manufacturer's Certificate of Conformance.

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Case 3058

Ni-Cr-Mo-Cu Alloy UNS N06235

Section VIII, Division 1

Approval Date: September 6, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May the wrought form of Ni-Cr-Mo-Cu Alloy (UNS N06235) ASTM B166-19 bar and rod; ASTM B366-20 fittings; ASTM B168-19 plate, sheet, and strip; ASTM B167-18 seamless pipe and tube; ASTM B619-19 and ASTM B626-19 welded pipe and tube, be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that Ni-Cr-Mo-Cu Alloy (UNS N06235) material, conforming to the specifications described in the Inquiry, may be used in welded construction under the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The material shall be supplied in the following condition: solution annealed between 2,100°F to 2,150°F (1150°C to 1175°C); and then either quenched in water or rapidly cooled by other means.

(b) The maximum design temperature is 1,600°F (870°C).

(c) The material's maximum allowable stress values shall be those listed in [Tables 1](#) and [1M](#).

(d) The material's tensile strength values shall be those listed in [Tables 2](#) and [2M](#).

(e) The material's yield strength values shall be those listed in [Tables 3](#) and [3M](#).

(f) The material's physical properties shall be those listed in [Tables 4](#) through [8](#) and [Tables 4M](#) through [8M](#).

(g) Separate welding procedure and performance qualifications in accordance with Section IX shall be required for this material. When welding this alloy to itself, the weld metal shall be of matching composition, and welding shall be limited to either solid bare-wire GTAW or GMAW processes. Postweld heat treatment (PWHT) for this material is not required.

(h) The rules of Subsection C, Part UNF for nickel alloys shall apply.

(i) For welded pipe and tube, the maximum allowable stress values shall be multiplied by 0.85.

(j) After cold working, a post-forming heat treatment shall be performed if:

(1) The design temperature range is 1,025°F to 1,200°F (550 to 650°C) and forming strains exceed 15%; or

(2) The design temperature exceeds 1,200°F (650°C) and forming strains exceed 10%

The heat treatment shall be performed in accordance with [\(a\)](#) for the time stipulated in [Tables 9](#) and [9M](#).

(k) In lieu of an external pressure chart, the rules of Mandatory Appendix 46 apply for external pressure and compressive stress calculations.

(l) This Case number shall appear in the marking and certification for the material and on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress Value, ksi [Note (1)], [Note (2)]	
	Low	High
100	23.3	23.3
200	21.2	23.3
300	19.5	23.3
400	17.9	23.3
500	16.7	22.5
600	15.8	21.4
650	15.5	21.0
700	15.3	20.7
750	15.2	20.5
800	15.1	20.4
850	15.1	20.4
900	15.1	20.4
950	15.1	20.4
1,000	15.1	15.9
1,050	13.1	13.1
1,100	9.9	9.9
1,150	7.5	7.5
1,200	5.6	5.6
1,250	4.3	4.3
1,300	3.3	3.3
1,350	2.6	2.6
1,400	2.1	2.1
1,450	1.7	1.7
1,500	1.3	1.3
1,550	1.0	1.0
1,600	0.8	0.8

NOTES:

- (1) For design at temperatures up to and including 1,000°F, the established maximum allowable stress is a range of values. This is because of the relatively low yield strength of the alloy. The maximum allowable stress range permits flexibility when slightly greater deformation is acceptable. At the given temperature, values in the range exceed 66²/₃% of the alloy's yield strength but do not exceed 90% of the yield strength. Use of the higher end of the range may result in dimensional changes due to permanent strain; and is not recommended for either the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) The stress values for 1,050°F and above are obtained from time-dependent properties.

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress Value, MPa [Note (1)], [Note (2)]	
	Low	High
40	161	161
65	152	161
100	145	161
125	139	161
150	134	161
175	129	161
200	124	161
225	120	161
250	116	157
275	113	153
300	111	149
325	108	146
350	107	144
375	105	142
400	105	141
425	104	141
450	104	140
475	104	140
500	104	140
525	104	135
550	104	106
575	82.2	82.2
600	63.8	63.8
625	49.5	49.5
650	38.5	38.5
675	30.2	30.2
700	23.9	23.9
725	19.1	19.1
750	15.4	15.4
775	12.6	12.6
800	10.4	10.4
825	8.1	8.1
850	6.9	6.9
875 [Note (3)]	5.1	5.1

NOTES:

- (1) For design at temperatures up to and including 550°C, the established maximum allowable stress is a range of values. This is because of the relatively low yield strength of the alloy. The maximum allowable stress range permits flexibility when slightly greater deformation is acceptable. At the given temperature, values in the range exceed $66\frac{2}{3}\%$ of the alloy's yield strength but do not exceed 90% of the yield strength. Use of the higher end of the range may result in dimensional changes due to permanent strain; and is not recommended for either the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) The stress values for 575°C and above are obtained from time-dependent properties.
- (3) The maximum use temperature shall be 870°C. Datum for 875°C temperature is provided for interpolation purposes.

Table 2
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °F	S_u Values, ksi
100	90.0
200	90.0
300	88.9
400	86.4
500	84.7
600	83.5
650	83.0
700	82.5
750	81.8
800	81.1
850	80.2
900	79.1
950	77.8
1,000	76.2
1,050	74.3
1,100	72.0
1,150	69.4
1,200	66.5
1,250	63.2
1,300	59.5
1,350	55.5
1,400	51.2
1,450	46.7
1,500	42.0
1,550	37.1
1,600	32.2

Table 2M
Tensile Strength Values, S_u

For Metal Temperature Not Exceeding, °C	S_u Values, MPa
40	621
65	621
100	621
125	621
150	612
175	604
200	597
225	591
250	586
275	582
300	578
325	575
350	571
375	568
400	564
425	560
450	554
475	548
500	540
525	531
550	520
575	507
600	493
625	476
650	458
675	437
700	415
725	390
750	364
775	337
800	308
825	278
850	248
875 [Note (1)]	217

NOTE: (1) The maximum design temperature shall be 870°C. Datum for 875°C temperature is provided for interpolation purposes.

Table 3
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °F	S_y Values, ksi
100	35.0
200	31.8
300	29.2
400	26.9
500	25.0
600	23.7
650	23.3
700	23.0
750	22.8
800	22.7
850	22.6
900	22.6
950	22.6
1,000	22.6
1,050	22.6
1,100	22.6
1,150	22.4
1,200	22.2
1,250	21.8
1,300	21.3
1,350	20.6
1,400	19.8
1,450	18.8
1,500	17.7
1,550	16.3
1,600	14.9

Table 3M
Yield Strength Values, S_y

For Metal Temperature Not Exceeding, °C	S_y Values, MPa
40	241
65	228
100	217
125	209
150	201
175	194
200	187
225	180
250	175
275	170
300	166
325	163
350	160
375	158
400	157
425	156
450	156
475	156
500	156
525	156
550	156
575	156
600	156
625	155
650	153
675	151
700	148
725	144
750	139
775	133
800	126
825	119
850	110
875 [Note (1)]	101

NOTE: (1) The maximum design temperature shall be 870°C. Datum for 875°C temperature is provided for interpolation purposes.

Table 4
Thermal Diffusivity

Temperature, °F	Thermal Diffusivity, ft ² /hr
70	0.108
100	0.110
125	0.112
150	0.114
200	0.116
250	0.119
300	0.122
350	0.124
400	0.127
450	0.129
500	0.132
550	0.135
600	0.139
650	0.141
700	0.145
750	0.148
800	0.151
850	0.154
900	0.158
950	0.161
1,000	0.162
1,050	0.166
1,100	0.169
1,150	0.171
1,200	0.173
1,250	0.175
1,300	0.177
1,350	0.179
1,400	0.183
1,450	0.181
1,500	0.182
1,550	0.183
1,600	0.182
1,650	0.186
1,700	0.187
1,750	0.189
1,800	0.191
1,850	0.192
1,900	0.194
1,950	0.197
2,000	0.200

Table 4M
Thermal Diffusivity

Temperature, °C	Thermal Diffusivity, 10 ⁻⁶ m ² /s
20	2.78
50	2.89
75	2.96
100	3.02
125	3.08
150	3.14
175	3.20
200	3.26
225	3.32
250	3.38
275	3.45
300	3.52
325	3.59
350	3.67
375	3.74
400	3.82
425	3.90
450	3.97
475	4.05
500	4.12
525	4.19
550	4.26
575	4.32
600	4.38
625	4.43
650	4.48
675	4.52
700	4.56
725	4.60
750	4.63
775	4.66
800	4.69
825	4.72
850	4.74
875	4.77
900	4.80
925	4.83
950	4.86
975	4.90
1000	4.94
1025	4.99
1050	5.04
1075	5.09
1100	5.15

Table 5
Thermal Conductivity

Temperature, °F	Thermal Conductivity, Btu/hr-ft-°F
70	5.8
100	6.0
125	6.1
150	6.2
200	6.4
250	6.7
300	6.9
350	7.2
400	7.4
450	7.6
500	7.9
550	8.1
600	8.5
650	8.7
700	8.9
750	9.2
800	9.5
850	9.8
900	10.0
950	10.3
1,000	10.4
1,050	10.8
1,100	11.0
1,150	11.3
1,200	11.4
1,250	11.7
1,300	11.9
1,350	12.1
1,400	12.5
1,450	12.4
1,500	12.6
1,550	12.8
1,600	12.7
1,650	13.1
1,700	13.3
1,750	13.4
1,800	13.6
1,850	13.8
1,900	14.0
1,950	14.2
2,000	14.5

Table 5M
Thermal Conductivity

Temperature, °C	Thermal Conductivity, W/m-K
20	10.0
50	10.5
75	10.9
100	11.3
125	11.6
150	12.0
175	12.4
200	12.7
225	13.1
250	13.5
275	13.9
300	14.3
325	14.7
350	15.1
375	15.5
400	15.9
425	16.4
450	16.8
475	17.2
500	17.6
525	18.0
550	18.4
575	18.8
600	19.2
625	19.5
650	19.9
675	20.2
700	20.5
725	20.8
750	21.1
775	21.3
800	21.6
825	21.9
850	22.1
875	22.4
900	22.7
925	22.9
950	23.2
975	23.5
1 000	23.8
1 025	24.1
1 050	24.4
1 075	24.8
1 100	25.1

Table 6
Coefficients of Thermal Expansion

Temperature, °F	Instantaneous Coefficient of Thermal Expansion, $\times 10^{-6}$ in./in./°F	Mean Coefficient of Thermal Expansion, $\times 10^{-6}$ in./in./°F	Linear Expansion, in./100 ft
70	6.3	6.3	0
100	6.6	6.5	0.23
125	6.7	6.6	0.43
150	6.7	6.6	0.64
200	6.8	6.8	1.1
250	7.0	6.9	1.5
300	7.1	7.0	1.9
350	7.2	7.1	2.4
400	7.3	7.1	2.8
450	7.5	7.2	3.3
500	7.6	7.3	3.7
550	7.7	7.3	4.2
600	7.9	7.4	4.7
650	8.0	7.4	5.2
700	8.1	7.5	5.6
750	8.3	7.5	6.1
800	8.4	7.5	6.6
850	8.6	7.6	7.1
900	8.7	7.6	7.6
950	8.9	7.7	8.1
1,000	9.0	7.7	8.6
1,050	9.2	7.8	9.1
1,100	9.3	7.9	9.7
1,150	9.5	8.0	10.3
1,200	9.7	8.1	10.9
1,250	9.8	8.1	11.5
1,300	10.0	8.2	12.1
1,350	10.2	8.3	12.7
1,400	10.3	8.4	13.4
1,450	10.5	8.4	14.0
1,500	10.7	8.5	14.6
1,550	10.8	8.6	15.2
1,600	11.0	8.7	15.9
1,650	11.2	8.7	16.6
1,700	11.4	8.8	17.2
1,750	11.6	8.9	17.9
1,800	11.8	9.0	18.6
1,850	12.0	9.0	19.3
1,900	12.1	9.1	20.0
1,950	12.3	9.2	20.8
2,000	12.5	9.3	21.5

Table 6M
Coefficients of Thermal Expansion

Temperature, °C	Instantaneous Coefficient of Thermal Expansion, $\times 10^{-6}$ mm/mm/°C	Mean Coefficient of Thermal Expansion, $\times 10^{-6}$ mm/mm/°C	Linear Expansion, mm/m
20	11.4	11.4	0
50	12.2	11.8	0.35
75	12.4	12.0	0.66
100	12.6	12.3	1.0
125	12.7	12.5	1.3
150	12.9	12.6	1.6
175	13.1	12.7	2.0
200	13.3	12.9	2.3
225	13.5	13.0	2.7
250	13.7	13.0	3.0
275	13.9	13.1	3.3
300	14.1	13.2	3.7
325	14.3	13.3	4.0
350	14.5	13.3	4.4
375	14.7	13.4	4.8
400	14.9	13.5	5.1
425	15.2	13.5	5.5
450	15.4	13.6	5.9
475	15.6	13.7	6.2
500	15.9	13.8	6.6
525	16.1	13.9	7.0
550	16.4	14.0	7.4
575	16.6	14.1	7.8
600	16.9	14.2	8.2
625	17.1	14.3	8.7
650	17.4	14.5	9.1
675	17.6	14.6	9.6
700	17.9	14.7	10.0
725	18.2	14.8	10.5
750	18.5	15.0	10.9
775	18.7	15.1	11.4
800	19.0	15.2	11.9
825	19.3	15.4	12.4
850	19.6	15.5	12.9
875	19.9	15.6	13.4
900	20.2	15.8	13.9
925	20.5	15.9	14.4
950	20.8	16.0	14.9
975	21.1	16.1	15.4
1 000	21.4	16.2	15.9
1 025	21.7	16.4	16.4
1 050	22.1	16.5	17.0
1 075	22.4	16.6	17.5
1 100	22.7	16.7	18.1

Table 7
Dynamic Modulus of Elasticity

Temperature, °F	Dynamic Modulus of Elasticity, $\times 10^6$ psi
75	28.2
100	28.2
200	27.7
300	27.5
400	26.9
500	26.5
600	26.1
700	25.5
800	25.2
900	24.6
1,000	24.3
1,100	23.5
1,200	23.2
1,300	22.3
1,400	21.9
1,500	20.9
1,600	20.4
1,700	18.9
1,800	18.7
1,900	17.3
2,000	17.1

Table 7M
Dynamic Modulus of Elasticity

Temperature, °C	Dynamic Modulus of Elasticity, $\times 10^3$ MPa
25	194
100	194
150	189
200	187
250	184
300	182
350	179
400	176
450	173
500	170
550	166
600	163
650	159
700	155
750	151
800	146
850	142
900	137
950	132
1 000	127
1 050	121
1 100	115

Table 8
Density and Poisson's Ratio

Density	0.295 lb/in. ³
Poisson's Ratio	0.32

Table 8M
Density and Poisson's Ratio

Density	8160 kg/m ³
Poisson's Ratio	0.32

Table 9
Post-Forming Annealing Time

Thickness, in.	Minutes
Less than 0.5	20
0.5 and greater	40 × (thickness)

Table 9M
Post-Forming Annealing Time

Thickness, mm	Minutes
Less than 12.7	20
12.7 and greater	$\frac{40}{25.4} \times (\text{thickness})$

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Case 3059

Unalloyed and Palladium or Ruthenium Enhanced Titanium H Grades With 400 MPa (58 ksi) Minimum UTS, UNS R50400, UNS R52400, UNS R52402, and UNS R52404

Section VIII, Division 2

Approval Date: September 6, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May unalloyed and palladium or ruthenium enhanced titanium H grades conforming to the requirements of Grades 2H, 7H, 16H, or 26H (UNS R50400, UNS R52400, UNS R52402, and UNS R52404) with a minimum 400 MPa (58 ksi) UTS be used in Section VIII, Division 2, Class 1 and Class 2 construction?

Reply: It is the opinion of the Committee that unalloyed and palladium or ruthenium enhanced titanium H grades conforming to the requirements of Grades 2H, 7H, 16H, or 26H (UNS R50400, UNS R52400, UNS R52402, and UNS R52404) with a minimum 400 MPa (58 ksi) UTS may be used on Section VIII, Division 2, Class 1 and Class 2 construction, provided the following requirements are met:

(a) The material shall meet all the requirements of the corresponding ASME Specifications in [Table 1](#).

(b) The maximum allowable stress values for Section VIII, Division 2, Class 1, shall be as shown in [Table 2](#) or [2M](#).

(c) The maximum allowable stress values, Section VIII, Division 2, Class 2, shall be as shown in [Table 3](#) or [3M](#).

(d) All other rules for Section VIII, Division 2 applicable to titanium shall be met.

(e) This Case number shall be shown on the Manufacturer's Data Report.

**Table 1
Product Specifications**

Product	Specification	Grade
Bar	SB-348/SB-348M	2H, 7H, 16H, 26H
Forgings	SB-381	F-2H, F-7H, F-16H, F-26H
Plate, sheet, strip	SB-265	2H, 7H, 16H, 26H
Seamless fittings	SB-363	WPT2H, WPT7H, WPT16H, WPT26H
Seamless pipe	SB-861	2H, 7H, 16H, 26H
Seamless tube	SB-338	2H, 7H, 16H, 26H
Welded fittings	SB-363	WPT2HW, WPT7HW, WPT16HW, WPT26H
Welded pipe	SB-862	2H, 7H, 16H, 26H
Welded tube	SB-338	2H, 7H, 16H, 26H

**Table 2
Maximum Allowable Stress Values for Section VIII, Division 2, Class 1 (All Product Forms)**

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
100	19.3
150	18.7
200	16.9
250	15.1
300	13.5
350	12.1
400	10.9
450	10.1
500	9.4
550	8.8
600 [Note (2)]	7.9

NOTES:

- (1) For welded pipe, tube, and fittings, a 0.85 efficiency factor shall be used.
- (2) The maximum design temperature shall be 600°F.

**Table 2M
Maximum Allowable Stress Values for Section VIII, Division 2, Class 1 (All Product Forms)**

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
40	133
65	129
100	113
125	102
150	92.4
175	83.7
200	76.6
225	70.9
250	66.5
275	63.2
300	57.8
325	53.0 [Note (2)]

NOTES:

- (1) For welded pipe, tube, and fittings, a 0.85 efficiency factor shall be used.
- (2) The maximum design temperature shall be 316°C.

Table 3
Maximum Allowable Stress Values for Section VIII,
Division 2, Class 2 (All Product Forms)

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]
100	24.2
150	23.5
200	20.8
250	18.2
300	15.9
350	14.0
400	12.4
450	11.0
500	9.8
550	8.8
600 [Note (2)]	7.9

NOTES:

- (1) For welded pipe, tube, and fittings, a 0.85 efficiency factor shall be used.
(2) The maximum design temperature shall be 600°F.

Table 3M
Maximum Allowable Stress Values for Section VIII,
Division 2, Class 2 (All Product Forms)

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa [Note (1)]
40	167
65	162
100	139
125	123
150	109
175	97.2
200	87.0
225	78.3
250	70.7
275	63.9
300	57.8
325	53.0 [Note (2)]

NOTES:

- (1) For welded pipe, tube, and fittings, a 0.85 efficiency factor shall be used.
(2) This value is given for interpolation only. The maximum design temperature shall be 316°C.

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Case 3060

Design of Components in the Time-Dependent Regime Using Isochronous Stress-Strain Method for Class 2 Components

Section VIII, Division 2

Approval Date: September 2, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May Section VIII, Division 2, Class 2 components operating in the time-dependent regime subjected to primary loads be analyzed using isochronous stress-strain method using Finite Element Analysis for margins against creep rupture and local creep damage?

Reply: It is the opinion of the Committee that Section VIII, Division 2, Class 2 components designed in the time-dependent regime may be analyzed using isochronous stress-strain method using Finite Element Analysis for margins against creep rupture and local creep damage as outlined in this Case.

1 NOMENCLATURE

A_0, A_1, A_2, A_3, A_4 = material coefficients for the MPC Project Omega strain-rate-parameter (see [Tables 2](#) and [2M](#))

B_0, B_1, B_2, B_3, B_4 = material coefficients for the MPC Project Omega Omega-parameter; (see [Tables 2](#) and [2M](#))

$C_0, C_1, C_2, C_3, C_4, C_5$ = curve-fit coefficients for the yield and tensile strength data

E_y = Young's Modulus

H = Prager doctor factor

K = parameter in the MPC stress strain curve model

m_1 = curve fitting exponent for the stress-strain curve equal to the true strain at the proportional limit and the strain hardening coefficient in the large strain region

n_{BN} = Bailey-Norton coefficient used in the MPC Project Omega Life Assessment Model

R = the ratio of engineering yield stress to engineering tensile stress evaluated at the assessment temperature

S_l = log base 10 of the effective stress

T = temperature (°F or °C)

t = time

T_{refa} = 460 for °F or 273 for °C (Reference Temperature)

α_Ω = triaxiality parameter based on the state of stress for MPC Project Omega Life Assessment Model

β_Ω = MPC Project Omega parameter to 0.33

$\Delta\Omega^{cd}$ = adjustment factor for creep ductility in the Project Omega Model, a range of +0.3 for brittle behavior and -0.3 for ductile behavior can be used

$\Delta\Omega^{sr}$ = adjustment factor for creep strain rate to account for the material scatter band in the Project Omega Model, a range of -0.5 for the bottom of the scatter band to +0.5 for the top of the scatter band can be used

ϵ_c = accumulated creep strain

$\dot{\epsilon}_{co}$ = initial creep strain rate at the start of the time period being evaluated based on the stress state and temperature; note, the units of measure for computing this parameter must be ksi and °F

ϵ_e = elastic strain

ϵ_p = true plastic strain or fitting parameter for MPC true stress strain curve model (see [Table 1](#))

ϵ_t = total true strain

ϵ_{ys} = engineering offset strain as defined by material specification

ϵ_1 = true plastic strain in the micro-strain region of the stress-strain curve

ϵ_2 = true plastic strain in the macro-strain region of the stress-strain curve

σ_{allow} = time-dependent allowable stress (ksi or MPa) at temperature from Section II, Table 1-A

σ_e = effective stress

σ_t = true stress

σ_{uts} = ultimate tensile strength at the assessment temperature (see [Tables 4](#) and [4M](#))

σ_{ys} = yield strength at the assessment temperature (see [Tables 3](#) and [3M](#))

$\sigma_1, \sigma_2, \sigma_3$ = principal stresses

- γ_1 = true strain in the micro-strain region of the stress-strain curve
 γ_2 = true strain in the macro-strain region of the stress-strain curve
 Ω = uniaxial Omega damage parameter
 Ω_m = multiaxial Omega damage parameter
 Ω_n = adjusted uniaxial Omega damage parameter

2 PROCEDURE TO CALCULATE CREEP DAMAGE USING ISOCHRONOUS METHOD

The isochronous stress-strain material model and the damage model used in this Case are based on MPC Project Omega [1].

Step 1. Generate isochronous stress-strain curve for 100,000 hr using MPC Project Omega Creep Data. See section 3 and refer to Section VIII, Division 2, Annex 3D [2] for stress-strain curve model. Note that 100,000 hr is used as the design life to be consistent with Section II, Part D, allowable stresses in the time dependent regime.

Step 2. Use an elastic plastic material model in the finite element analysis with the elastic properties from Section II, Part D, and the flow curve from isochronous curve, and standard von Mises flow theory.

Step 3. Calculate the creep damage. See section 4.

Step 4. For multiple design conditions the total time for design shall be 100,000 hr. See section 4 on how to generate the isochronous stress strain curves and to calculate the total creep damage.

3 ISOCHRONOUS STRESS-STRAIN CURVE

The isochronous stress strain curves are calculated using eq. (1). Since ϵ_e and ϵ_p are functions of the material of construction, stress, and temperature, and ϵ_c is a function of the material of construction, stress, temperature, and time, the specification of a time of interest yields a closed form equation for an isochronous stress strain curve.

$$\epsilon_t(t) = \epsilon_e + \epsilon_p + \epsilon_c(t) \quad (1)$$

where

$$\epsilon_i(t) = \frac{\sigma_t}{E_y} + \epsilon_c(t) \text{ if } (\gamma_1 + \gamma_2) \leq \epsilon_p \quad (2)$$

$$\epsilon_t(t) = \frac{\sigma_t}{E_y} + \gamma_1 + \gamma_2 + \epsilon_c(t) \text{ if } (\gamma_1 + \gamma_2) > \epsilon_p \quad (3)$$

$$\gamma_1 = \frac{\epsilon_1}{2}(1.0 - \tanh[H]) \quad (4)$$

$$\gamma_2 = \frac{\epsilon_2}{2}(1.0 + \tanh[H]) \quad (5)$$

$$\epsilon_1 = \left(\frac{\sigma_t}{X_1} \right)^{\frac{1}{m_1}} \quad (6)$$

$$X_1 = \frac{\sigma_{ys}(1 + \epsilon_{ys})}{\left[\ln(1 + \epsilon_{ys}) \right]^{m_1}} \quad (7)$$

$$m_1 = \frac{\ln(R) + (\epsilon_p - \epsilon_{ys})}{\ln\left(\frac{\ln(1 + \epsilon_p)}{\ln(1 + \epsilon_{ys})} \right)} \quad (8)$$

$$\epsilon_2 = \left(\frac{\sigma_t}{X_2} \right)^{\frac{1}{m_2}} \quad (9)$$

$$X_2 = \frac{\sigma_{uts} \exp(m_2)}{m_2^{m_2}} \quad (10)$$

$$H = \frac{2 \left\{ \sigma_t - \left[\sigma_{ys} + K(\sigma_{uts} - \sigma_{ys}) \right] \right\}}{K(\sigma_{uts} - \sigma_{ys})} \quad (11)$$

$$R = \frac{\sigma_{ys}}{\sigma_{uts}} \quad (12)$$

$$\epsilon_{ys} = 0.002 \quad (13)$$

$$K = 1.5R^{1.5} - 0.5R^{2.5} - R^{3.5} \quad (14)$$

$$\epsilon_c = \frac{1}{\Omega} \ln(1 - \dot{\epsilon}_{co} \Omega t) \quad (15)$$

The parameters m_2 and ϵ_p along with equations to calculate σ_{ys} and σ_{uts} are given in the applicable table in this Case.

$$\dot{\epsilon}_{co} = 10^{-\left[\left(A_0 + \Delta \Omega^{sr} \right) + \left(\frac{1}{T_{refa} + T} \right) (A_1 + A_2 S_l + A_3 S_l^2 + A_4 S_l^3) \right]} \quad (16)$$

$$\Omega = 10^{\left[\left(B_0 + \Delta \Omega^{cd} \right) + \left(\frac{1}{T_{refa} + T} \right) (B_1 + B_2 S_l + B_3 S_l^2 + B_4 S_l^3) \right]} \quad (17)$$

$$S_l = \log_{10}(\sigma_e) \quad (18)$$

Omega constants in eqs. (16) to (18) are given in the applicable table for different materials. The total strains from eq. (1) with the corresponding stresses are used to obtain the isochronous stress-strain curve.

100,000 hr shall be used as design life and Δ_{Ω}^{cd} shall be equal to 0.0. Δ_{Ω}^{sr} shall be calculated using eq. (19).

$$\Delta_{\Omega}^{sr} = (S + B_0 - A_0) + \left(\frac{(B_1 - A_1) + (B_2 - A_2)S_a + (B_3 - A_3)S_a^2 + (B_4 - A_4)S_a^3}{T + T_{refa}} \right) \quad (19)$$

$$S_a = \log_{10}(\sigma_{allow}) \quad (20)$$

4 ISOCHRONOUS DAMAGE MODEL

The creep and plastic strains are implemented in the finite element model as plastic property definition. The finite element model is then solved with the nonlinear geometry option. Once the analysis is completed, the amount of creep damage is calculated as shown below at every node in the model. The damage is then averaged on an element basis and then contoured to quantify the damage in the component. The procedure to calculate the damage at each node is as follows:

Calculate the von Mises equivalent stress at each node.

$$\sigma_e = \frac{1}{\sqrt{2}} \sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2} \quad (21)$$

$$S_l = \log_{10}(\sigma_e) \quad (22)$$

Calculate the damage parameter exponent for MPC Project Omega Life Assessment Model.

$$\delta_{\Omega} = \beta_{\Omega} \left(\frac{\sigma_1 + \sigma_2 + \sigma_3}{\sigma_e} - 1.0 \right) \quad (23)$$

where

$$\beta_{\Omega} = 0.33$$

Calculate Omega uniaxial damage parameter.

$$\Omega = 10 \left[(B_0 + \Delta_{\Omega}^{cd}) + \left(\frac{1}{T_{refa} + T} \right) (B_1 + B_2 S_l + B_3 S_l^2 + B_4 S_l^3) \right] \quad (24)$$

where Δ_{Ω}^{cd} is assumed zero if there is no adjustment for creep ductility.

Calculate Omega multi-axial damage using eqs. (25) and (26).

$$\Omega_m = \Omega_n^{\delta_{\Omega} + 1} + \alpha_{\Omega} n_{BN} \quad (25)$$

$$\Omega_n = \max[(\Omega - n_{BN}), 3.0] \quad (26)$$

where

$$n_{BN} = \left(\frac{A_2 + 2A_3 S_l + 3A_4 S_l^2}{T_{refa} + T} \right) \quad (27)$$

Note that when nonlinear geometry is considered in finite element stress analysis, then $\alpha_{\Omega} = 0$. Otherwise, $\alpha_{\Omega} = 1$.

Calculate the strain rate at the end of the time period using eq. (28).

$$\dot{\epsilon}_{co} = 10^{-6} \left[\left(A_0 + \Delta_{\Omega}^{sr} \right) + \left(\frac{1}{T_{refa} + T} \right) (A_1 + A_2 S_l + A_3 S_l^2 + A_4 S_l^3) \right] \quad (28)$$

where Δ_{Ω}^{sr} is obtained from 3, eq. (19)

$$\text{Damage} = \dot{\epsilon}_{co} \times \Omega_m \times t \quad (29)$$

where

$$t = 100,000 \text{ hr}$$

The damage averaged on the element shall be less than one.

5 MULTIPLE DESIGN CONDITIONS USING ISOCHRONOUS METHOD

For multiple design conditions, the total design life shall be 100,000 hr. For all load cases, Δ_{Ω}^{sr} shall be calculated using 3, eq. (19) using 100,000 hr as the basis. For example, if there are two load cases, one is 80,000 hr (t_1) at 1,100°F and the other is 20,000 hr (t_2) at 1,250°F, then do the following:

(a) For Load Case 1, calculate the Δ_{Ω}^{sr} using 100,000 hr at 1,100°F and then use this Δ_{SR} to generate the isochronous curve for 80,000 hr (t_1) at 1,100°F to use in the analysis.

(b) For Load Case 2, calculate the Δ_{Ω}^{sr} using 100,000 hr at 1,250°F and then use this Δ_{SR} to generate the isochronous curves for 80,000 hr (t_1) at 1,250°F and for 100,000 ($t_1 + t_2$) at 1,250°F. Note that 100,000 hr minus 80,000 hr is equal to 20,000 hr. Use these two curves and the isochronous curve from Load Case 1 to generate the isochronous curve to be used in the analysis as shown below.

For load, temperature, and time condition 1 (t_1), calculate the creep strain ϵ_{c1} using 3, eq. (15) and add that to the plastic and elastic strain for the various stress levels to generate the isochronous curve.

Table 1
Stress-Strain Curve Parameters

Material	Temperature Limit, °C (°F)	m_2	ϵ_p
Ferritic Steel	480 (900)	0.60 (1.00 - R)	2.0 E-5
Stainless Steel and Nickel Base Alloys	480 (900)	0.75 (1.00 - R)	2.0 E-5
Duplex Stainless Steel	480 (900)	0.70 (0.95 - R)	2.0 E-5
Precipitation Hardenable Nickel Base	540 (1,000)	1.09 (0.93 - R)	2.0 E-5
Aluminum	120 (250)	0.52 (0.98 - R)	5.0 E-6
Copper	65 (150)	0.50 (1.00 - R)	5.0 E-6
Titanium and Zirconium	260 (500)	0.50 (0.98 - R)	2.0 E-5

GENERAL NOTE: This Table originally appears in Section VIII, Division 2 as Table 3-D.1.

For load, temperature, and time condition 2 (t_2), calculate the creep strain as shown in eq. (30). This creep strain is then added to the elastic and plastic strain to obtain total strain, which is then used to generate the isochronous curve.

$$\epsilon_{c2} = \epsilon_{c1}^{t_1} + \left(\epsilon_{c2}^{(t_2+t_1)} - \epsilon_{c2}^{t_1} \right) \quad (30)$$

For load, temperature, and time condition n , calculate the creep strains for the isochronous curve as follows:

$$\epsilon_{cn} = \epsilon_{c1}^{t_1} + \left(\epsilon_{c2}^{(t_2+t_1)} - \epsilon_{c2}^{t_1} \right) \dots \left(\epsilon_{cn}^{(t_n+t_{n-1}+t_{n-2}\dots)} - \epsilon_{cn}^{(t_{n-1}+t_{n-2}\dots)} \right) \quad (31)$$

where

$$n = 2, 3, 4, 5, \dots$$

The isochronous curve for each load condition should be implemented in the finite element model and analyzed independently. Note that in finite element model, the creep and plastic strains are combined and applied as plastic property definition. The damage from each load condition is then calculated and the total damage is then obtained by adding the damages for all the load conditions. The total damage shall be less than or equal to one.

6 REQUIREMENTS

(a) All other requirements of Section VIII, Division 2 shall be met.

(b) This Case number shall be included in the Manufacturer's Data Report (MDR).

7 CAUTIONARY NOTE

Isochronous method will give conservative results for thermally induced stresses.

8 REFERENCES

[1] API-579-1/ASME FFS-1, December 2021, Fitness for Service.

[2] ASME Boiler & Pressure Vessel Code, Section VIII, Division 2, Rules for Construction of Pressure Vessels, Alternative Rules.

Table 2
Omega Parameters (ksi, °F)

Material	A_0	A_1	A_2	A_3	A_4	B_0	B_1	B_2	B_3	B_4
Carbon steel, $\sigma_{uts} \leq 55$ ksi	-16.00	35,192.86	-3,310.23	-2,132.35	-457.87	-1.00	3,124.49	-48.08	-538.96	174.98
Carbon steel, $\sigma_{uts} = 60$ ksi	-16.00	35,240.34	-3,275.6	-2,037.11	-422.29	-1.00	3,171.97	-126.8	-443.71	143.91
Carbon steel, $\sigma_{uts} = 65$ ksi	-16.00	35,287.87	-3,241.77	-1,940.56	-387.21	-1.00	3,219.50	-206.32	-347.17	112.34
Carbon steel, $\sigma_{uts} = 70$ ksi	-16.00	35,335.58	-3,209.1	-1,842.53	-352.63	-1.00	3,267.21	-287	-249.14	80.27
Carbon steel, $\sigma_{uts} \geq 75$ ksi	-16.00	35,383.50	-3,177.71	-1,742.84	-318.62	-1.00	3,315.14	-368.96	-149.44	47.63
C- $\frac{1}{2}$ Mo	-19.50	61,000	-49,000	33,000	-8,000	-1.30	4,500	2,000	-4,500	2,000
1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo (N&T) (Use only below 1,000°F) [Note (1)] , [Note (2)]	-23.35	62,070.00	-47,520.00	43,800.00	-14,790.00	-4.40	14,510.00	-24,671.00	29,384.00	-10,630.00
1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo (Annealed) [Note (1)] , [Note (2)]	-23.50	52,787	-5,965.5	-2,621	-384	-2.65	6,287	1,534.50	-1,871	166
2 $\frac{1}{4}$ Cr-1Mo (N&T) (Use only below 950°F) [Note (1)] , [Note (2)]	-21.56	55,526.00	-10,985.90	-1,560.17	-73.86	-1.12	5,040.00	-435.90	-2,175.17	1,136.14
2 $\frac{1}{4}$ Cr-1Mo (Annealed) [Note (1)] , [Note (2)]	-21.86	51,669	-7,597.4	-2,131	-199.3	-1.85	7,195.00	-2,358.00	-127.40	56.20
2 $\frac{1}{4}$ Cr-1Mo (Q&T) (Use only below 950°F)	-21.56	55,530.00	-11,005.8	-1,544.00	-72.21	-1.12	5,044.00	-455.80	-2,159.00	1,137.79
2 $\frac{1}{4}$ Cr-1 Mo-V (Use only below 950°F)	-25.00	52,210.50	-936.7	-1,814.00	-1,171.00	-2.52	5,797.60	-364.80	-228.20	294.90
5Cr- $\frac{1}{2}$ Mo	-22.40	51,668.70	-7,597.37	-2,131.00	-199.27	-1.40	5,019.24	-1,207.62	221.32	89.43
9Cr-1Mo	-22.55	51,473.00	-7,027.30	-1,718.00	-140.60	-2.05	6,410.80	-1,426.60	-69.00	83.80
9Cr-1Mo-V	-34.00	73,285	-3,428	-3,433	-1,146.17	-2.00	7,185	-1,231.72	-449.28	205.22
12Cr	-30.29	67,110.00	-21,093.00	14,556.00	-5,884.00	-3.30	6,508.00	3,016.00	-2,784.00	480
Types 304 and 304H	-19.17	53,762.40	-13,442.40	3,162.60	-1,685.20	-3.40	11,250	-5,635.80	3,380.40	-993.60
Types 316 and 316H	-18.90	57,261.50	-18,656.00	3,866.86	-267.16	-4.16	17,176.26	-13,216.00	4,973.80	-67.36
Type 321	-19.00	49,425.00	-7,417.00	1,240.00	-129.00	-3.40	10,625	-3,217.00	1,640.00	-490.00
Type 321H	-18.4	49,425	-7,417	1,240	-1,290	-3.4	10,625	-3,217	1,640	-490
Type 347 [Note (1)] , [Note (2)]	-18.3	47,140	-5,434	500	-1,128	-3.5	10,000	-800	-100	100
Type 347H [Note (1)] , [Note (2)]	-17.7	47,140	-5,434	500	-1,128	-3.65	10,000	-800	-100	100
Alloy 800 [Note (1)] , [Note (2)]	-19.4	55,548	-15,877	3,380	-993	-3.6	11,250	-5,635	3,380	-993
Alloy 800H [Note (1)] , [Note (2)]	-18.8	55,548	-15,877	3,380	-993	-3.6	11,250	-5,635	3,380	-993
Alloy 800HT [Note (1)] , [Note (2)]	-20.25	59,445	-14,123	41.42	-0.0405	-3.4	11,195	-4,848.5	1,556	82.42

GENERAL NOTE: σ_{uts}^{\min} is the minimum specified ultimate tensile strength at room temperature.

NOTES:

(1) Coefficients in this Table are estimates of the typical material behavior (center of scatter band) based on the MPC Project Omega Materials data from service-aged materials at design stress levels.

Table 2
Omega Parameters (ksi, °F) (Cont'd)

NOTES: (Cont'd)

- (2) The coefficients in this Table are intended to describe material behavior in the range of the ASME Code design allowable stress for a given material at a specified temperature. These coefficients may be used to estimate the stress relaxation resulting from creep over a similar stress range.

Table 2M
Omega Parameters (MPa, °C)

Material	A_0	A_1	A_2	A_3	A_4	B_0	B_1	B_2	B_3	B_4
Carbon steel, $\sigma_{\text{uts}} \leq 379$ MPa	-16.00	20410.67	-388.827	-544.7574	-254.3703	-1	1490.383	680.4895	-543.968	97.21306
Carbon steel, $\sigma_{\text{uts}} = 413$ MPa	-16.00	20446.47	-416.6975	-541.5552	-234.6082	-1	1600.815	511.5982	-447.6203	79.94735
Carbon steel, $\sigma_{\text{uts}} = 448$ MPa	-16.00	20483.34	-446.7459	-536.9449	-215.1184	-1	1712.316	340.4734	-349.8646	62.40938
Carbon steel, $\sigma_{\text{uts}} = 483$ MPa	-16.00	20521.59	-479.4071	-530.8094	-195.9077	-1	1825.205	166.7357	-250.5836	44.59233
Carbon steel, $\sigma_{\text{uts}} \geq 517$ MPa	-16.00	20561.40	-514.9966	-522.9561	-177.0129	-1	1939.644	-9.930231	-149.5848	26.45936
C- $\frac{1}{2}$ Mo	-19.500	72225.994	-67342.772	29513.586	-4444.444	-1.300	-844.556	7647.419	-5295.063	1111.111
$1\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo (N&T) (Use only below 1,000°F) [Note (1)], [Note (2)]	-23.350	78573.680	-84539.684	45002.826	-8216.667	-4.400	34513.656	-53539.661	31180.205	-5905.556
$1\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo (Annealed) [Note (1)], [Note (2)]	-23.5	31207.07	-1322.206	-919.459	-213.333	-2.65	1992.72	2790.216	-1271.435	92.222
$2\frac{1}{4}$ Cr-1 Mo (N&T) (Use only below 950°F) [Note (1)], [Note (2)]	-21.560	35380.252	-4736.240	-736.539	-41.033	-1.120	1781.266	3115.806	-2796.219	631.189
$2\frac{1}{4}$ Cr-1 Mo (Annealed) [Note (1)], [Note (2)]	-21.86	31477.07	-2468.902	-905.361	-110.722	-1.85	5027.509	-1125.445	-149.319	31.222
$2\frac{1}{4}$ Cr-1Mo (Q&T) (Use only below 510°C)	-21.56	35397.52	-4760.427	-756.862	-40.117	-1.12	1798.534	3091.619	-2789.542	632.106
$2\frac{1}{4}$ Cr-1Mo-V (Use only below 510°C)	-25.00	29117.17	-202.661	628.984	650.711	-2.52	3205.108	355.458	-538.837	163.814
5Cr- $\frac{1}{2}$ Mo	22.400	31476.822	-2468.850	-905.403	-110.706	-1.400	3408.189	-772.302	-2.026	49.683
9Cr-1Mo	-22.550	31244.705	-2468.179	-757.951	-78.111	-2.050	4171.728	-630.067	-155.446	46.566
9Cr-1Mo-V	-34.000	41345.225	-49.107	-305.413	-636.761	-2.000	4322.741	-25.212	-536.401	114.011
12Cr	-30.29	54722.48	-32175.19	16309.74	3268.889	-3.29	965.868	4831.865	-2217.482	266.667
Types 304 and 304H	-19.170	37917.404	-12389.369	4112.120	-936.222	-3.400	10521.296	-7444.834	3266.587	-552.000
Types 316 and 316H	-18.900	42100.704	-14280.229	2521.626	-148.424	-4.163	17663.885	-12055.190	2857.364	-37.424
Type 321	-19.000	31820.393	-6787.544	2491.705	-716.667	-3.400	8202.508	-3889.400	1595.902	-272.222
Type 321H	-18.400	31820.393	-6787.544	2491.705	-716.667	-3.400	8202.508	-3889.400	1595.902	-272.222
Type 347 [Note (1)], [Note (2)]	-18.300	29285.061	-4806.587	1854.193	-626.667	-3.500	5856.415	-234.090	-195.309	55.556
Type 347H [Note (1)], [Note (2)]	-17.700	29285.061	-4806.587	1854.193	-626.667	-3.650	5856.415	-234.090	-195.309	55.556
Alloy 800 [Note (1)], [Note (2)]	-19.400	39901.744	-13133.314	3265.527	-551.667	-3.600	10520.571	-7443.314	3265.527	-551.667
Alloy 800H [Note (1)], [Note (2)]	-18.800	39901.744	-13133.314	3265.527	-551.667	-3.600	10520.571	-7443.314	3265.527	-551.667
Alloy 800HT [Note (1)], [Note (2)]	-20.250	39620.306	-7884.749	23.068	-0.023	-3.400	9058.896	-4046.733	749.260	45.789

GENERAL NOTE: $\sigma_{\text{uts}}^{\text{min}}$ is the minimum specified ultimate tensile strength at room temperature.

NOTES:

(1) Coefficients in this Table are estimates of the typical material behavior (center of scatter band) based on the MPC Project Omega Materials data from service-aged materials at design stress levels.

Table 2M
Omega Parameters (MPa, °C) (Cont'd)

NOTES: (Cont'd)

- (2) The coefficients in this Table are intended to describe material behavior in the range of the ASME Code design allowable stress for a given material at a specified temperature. These coefficients may be used to estimate the stress relaxation resulting from creep over a similar stress range.

Table 3
Yield Strength (ksi, °F)

Material	YS, ksi	T_{\min} °F	T_{\max} °F	C_0	C_1	C_2	C_3	C_4	C_5
Carbon Steel	30-45	70	1,050	1.110274	-1.952789 E-03	7.386921 E-06	-1.485792 E-08	1.322039 E-11	-4.312526 E-15
C- $\frac{1}{2}$ Mo	28	70	1,100	1.041915	-5.803618 E-04	2.323549 E-07	8.761543 E-10	-1.469796 E-12	5.327452 E-16
1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo	30	70	1,100	1.060272	-8.879304 E-04	1.185142 E-06	-9.126022 E-10	2.512551 E-13	-7.008346 E-17
2 $\frac{1}{4}$ Cr-1Mo	30	70	1,100	1.056469	-9.001587 E-04	1.617049 E-06	-8.729456 E-10	-3.074254 E-14	-7.828849 E-17
5Cr- $\frac{1}{2}$ Mo	30	70	1,300	1.101864	-1.633481 E-03	3.954630 E-06	-3.866350 E-09	9.307023 E-13	1.281434 E-16
9Cr-1Mo	30	70	1,300	1.101864	-1.633481 E-03	3.954630 E-06	-3.866350 E-09	9.307023 E-13	1.281434 E-16
9Cr-1Mo-V	60	70	1,100	1.078963	-1.269316 E-03	3.244157 E-06	-2.966921 E-09	3.550899 E-13	2.276568 E-16
Types 304 and 304H	30	70	1,300	1.146768	-2.247707 E-03	4.249289 E-06	-4.708893 E-09	2.732244 E-12	-6.538660 E-16
Types 316 and 316H	30	70	1,300	1.101270	-1.458670 E-03	1.481820 E-06	-7.307220 E-10	2.865970 E-13	-1.142740 E-16
Type 321	30	70	1,300	1.065340	-8.909010 E-04	1.772090 E-07	5.829130 E-10	-3.340520 E-13	0
Type 321H	30	70	1,300	1.07 E+00	-8.91 E-04	1.77 E-07	5.83 E-10	-3.34 E-13	0.00 E+00
Type 347	30	70	1,300	1.04 E+00	-5.17 E-04	-7.41 E-07	1.57 E-09	-6.86 E-13	0.00 E+00
Type 347H	30	70	1,500	1.04 E+00	-5.50 E-04	-6.16 E-07	1.37 E-09	-5.49 E-13	-3.49 E-17
Alloy 800	30	70	1,300	1.07 E+00	-1.15 E-03	2.81 E-06	-4.32 E-09	3.31 E-12	-9.98 E-16
Alloy 800H	25	70	1,300	1.06 E+00	-7.92 E-04	7.35 E-07	-9.37 E-10	8.65 E-13	-3.07 E-16
Alloy 800HT	25	70	1,300	1.06 E+00	-7.92 E-04	7.35 E-07	-9.37 E-10	8.65 E-13	-3.07 E-16

GENERAL NOTE: The following equation applies to this Table:

$$\sigma_y = YS(C_0 + C_1T + C_2T^2 + C_3T^3 + C_4T^4 + C_5T^5)$$

Table 3M
Yield Strength (MPa, °C)

Material	YS, MPa	T_{\min} °C	T_{\max} °C	C_0	C_1	C_2	C_3	C_4	C_5
Carbon steel	206-310	21	566	1.0549	-2.7431 E-03	1.9571 E-05	-7.7040 E-08	1.3154 E-10	-8.1488 E-14
C- $\frac{1}{2}$ Mo	193	21	593	1.0236	-1.0134 E-03	9.9666 E-07	4.0444 E-09	-1.4535 E-11	1.0067 E-14
1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo	207	21	593	1.0330	-1.4667 E-03	3.5609 E-06	-5.1389 E-09	2.5199 E-12	-1.3243 E-15
2 $\frac{1}{4}$ Cr-1Mo	207	21	593	1.0293	-1.4388 E-03	4.9670 E-06	-5.1186 E-09	-4.5422 E-13	-1.4793 E-15
5Cr- $\frac{1}{2}$ Mo	207	21	704	1.0535	-2.5059 E-03	1.1629 E-05	-2.1846 E-08	9.9854 E-12	2.4214 E-15
9Cr-1Mo	207	21	704	1.0535	-2.5059 E-03	1.1629 E-05	-2.1846 E-08	9.9854 E-12	2.4214 E-15
9Cr -1Mo-V	414	21	593	1.0416	-1.9274 E-03	9.5955 E-06	-1.7024 E-08	4.1100 E-12	4.3017 E-15
Types 304 and 304H	207	21	704	1.0790	-3.5818 E-03	1.2357 E-05	-2.5462 E-08	2.7584 E-11	-1.2355 E-14
Types 316 and 316H	207	21	704	1.0561	-2.4589 E-03	4.5794 E-06	-4.0545 E-09	2.8166 E-12	-2.1593 E-15
Type 321	207	21	704	1.0370	-1.5801 E-03	7.4882 E-07	3.1502 E-09	-3.5067 E-12	0.0000 E+00
Type 321H	207	21	704	1.0417	-1.5803 E-03	7.4817 E-07	3.1507 E-09	-3.5062 E-12	0.0000 E+00
Type 347	207	21	704	1.0227	-1.0074 E-03	-1.9262 E-06	8.6441 E-09	-7.2014 E-12	0.0000 E+00
Type 347H	207	21	816	1.0218	-1.0535 E-03	-1.5807 E-06	7.5779 E-09	-5.8218 E-12	-6.5946 E-16
Alloy 800	207	21	704	1.0359	-1.7694 E-03	7.8255 E-06	-2.2783 E-08	3.3071 E-11	-1.8858 E-14
Alloy 800H	172	21	704	1.0354	-1.3459 E-03	2.1068 E-06	-4.8372 E-09	8.5648 E-12	-5.8010 E-15
Alloy 800HT	172	21	704	1.0354	-1.3459 E-03	2.1068 E-06	-4.8372 E-09	8.5648 E-12	-5.8010 E-15

GENERAL NOTE: The following equation applies to this Table:

$$\sigma_y = YS(C_0 + C_1T + C_2T^2 + C_3T^3 + C_4T^4 + C_5T^5)$$

Table 4
Tensile Strength (ksi, °F)

Material	TS, ksi	T_{min} °F	T_{max} °F	C_0	C_1	C_2	C_3	C_4	C_5
Carbon Steel	40-75	70	1,050	0.976706	6.66203 E-04	-6.03804 E-06	1.92536 E-08	-2.40578 E-11	9.72338 E-15
C- $\frac{1}{2}$ Mo	53	70	1,100	1.059525	-8.141874 E-04	8.466784 E-07	2.853639 E-09	-5.349197 E-12	2.137446 E-15
1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo	60	70	1,100	1.006816	7.472253 E-05	-3.219189 E-06	9.855387 E-09	-1.044150 E-11	3.462704 E-15
2 $\frac{1}{4}$ Cr-1Mo	60	70	1,100	1.091114	-1.384682 E-03	2.297709 E-06	7.834140 E-10	-3.043512 E-12	1.072040 E-15
5Cr- $\frac{1}{2}$ Mo	60	70	1,300	1.105143	-1.715655 E-03	4.521454 E-06	-4.705968 E-09	1.226905 E-12	1.587304 E-16
9Cr-1Mo	60	70	1,300	1.105143	-1.715655 E-03	4.521454 E-06	-4.705968 E-09	1.226905 E-12	1.587304 E-16
9Cr-1Mo-V	85	70	1,100	1.083635	-1.363617 E-03	3.696590 E-06	-3.901765 E-09	9.603436 E-13	1.349062 E-16
Type 304	75	70	1,300	1.128241	-1.982862 E-03	3.735230 E-06	-2.568024 E-09	2.172525 E-13	1.657173 E-16
Type 316	75	70	1,300	1.078890	-1.243150 E-03	2.452110 E-06	-1.604850 E-09	-6.961690 E-14	1.656230 E-16
Type 321	75	70	1,300	1.136240 E+00	-2.125410 E-03	4.436980 E-06	-3.480260 E-09	8.061010 E-13	0
Type 321H	75	70	1,300	1.14 E+00	-2.13 E-03	4.44 E-06	-3.48 E-09	8.06 E-13	0.00 E+00
Type 347	75	70	1,300	1.11 E+00	-1.57 E-03	2.07 E-06	-8.70 E-10	-3.59 E-14	0.00 E+00
Type 347H	75	70	1,500	1.10 E+00	-1.51 E-03	1.85 E-06	-5.34 E-10	-2.62 E-13	5.49 E-17
Alloy 800	75	70	1,300	1.06 E+00	-9.41 E-04	2.23 E-06	-2.60 E-09	1.62 E-12	-5.20 E-16
Alloy 800H	65	70	1,300	1.03 E+00	-3.97 E-04	-1.83 E-07	1.49 E-09	-1.36 E-12	2.94 E-16
Alloy 800HT	65	70	1,300	1.03 E+00	-3.97 E-04	-1.83 E-07	1.49 E-09	-1.36 E-12	2.94 E-16

GENERAL NOTE: The following equation applies to this Table:

$$\sigma_{uts} = \min \left[TS, 1.1TS \left(C_0 + C_1T + C_2T^2 + C_3T^3 + C_4T^4 + C_5T^5 \right) \right]$$

Table 4M
Tensile Strength (MPa, °C)

Material	TS, MPa	T_{\min} , °C	T_{\max} , °C	C_0	C_1	C_2	C_3	C_4	C_5
Carbon steel	276–517	21	566	0.9924	6.0446 E-04	-1.4043 E-05	9.4909 E-08	-2.3622 E-10	1.8373 E-13
C- $\frac{1}{2}$ Mo	365	21	593	1.0344	-1.3535 E-03	3.5266 E-06	1.2777 E-08	-5.2564 E-11	4.0388 E-14
1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo	414	21	593	1.0062	-1.8428 E-04	-7.5689 E-06	4.9889 E-08	-1.0379 E-10	6.5430 E-14
2 $\frac{1}{4}$ Cr-1Mo	414	21	593	1.0492	-2.2241 E-03	7.6288 E-06	2.3609 E-09	-3.0149 E-11	2.0257 E-14
5Cr- $\frac{1}{2}$ Mo	414	21	704	1.0547	-2.5930 E-03	1.3210 E-05	-2.6520 E-08	1.3146 E-11	2.9993 E-15
9Cr-1Mo	414	21	704	1.0547	-2.5930 E-03	1.3210 E-05	-2.6520 E-08	1.3146 E-11	2.9993 E-15
9Cr-1Mo-V	586	21	593	1.0437	-2.0500 E-03	1.0783 E-05	-2.2030 E-08	1.0308 E-11	2.5491 E-15
Types 304 and 304H	517	21	704	1.0685	-3.1530 E-03	1.1308 E-05	-1.4805 E-08	2.5590 E-12	3.1313 E-15
Types 316 and 316H	517	21	704	1.0416	-1.9641 E-03	7.4445 E-06	-9.4016 E-09	-4.5263 E-13	3.1296 E-15
Type 321	517	21	704	1.0727	-3.3337 E-03	1.3309 E-05	-1.9695 E-08	8.4621 E-12	0.0000 E+00
Type 321H	517	21	704	1.0763	-3.3416 E-03	1.3319 E-05	-1.9694 E-08	8.4611 E-12	0.0000 E+00
Type 347	517	21	704	1.0619	-2.5924 E-03	6.4355 E-06	-5.1006 E-09	-3.7686 E-13	0.0000 E+00
Type 347H	517	21	816	1.0536	-2.5079 E-03	5.8227 E-06	-3.3066 E-09	-2.6582 E-12	1.0374 E-15
Alloy 800	517	21	704	1.0321	-1.4509 E-03	6.4482 E-06	-1.3985 E-08	1.6133 E-11	-9.8258 E-15
Alloy 800H	448	21	704	1.0172	-7.2776 E-04	-1.5623 E-07	7.6920 E-09	-1.3783 E-11	5.5553 E-15
Alloy 800HT	448	21	704	1.0172	-7.2776 E-04	-1.5623 E-07	7.6920 E-09	-1.3783 E-11	5.5553 E-15

GENERAL NOTE: The following equation applies to this Table:

$$\sigma_{\text{uts}} = \min \left[\text{TS}, 1.1 \text{TS} \left(C_0 + C_1 T + C_2 T^2 + C_3 T^3 + C_4 T^4 + C_5 T^5 \right) \right]$$

Case 3061

Use of UNS S31042 Austenitic Stainless Steel in the Form of ASTM A213/A213M-21b Seamless Tube in Construction

Section I

Approval Date: October 17, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S31042 austenitic stainless steel in the form of ASTM A213/A213M-21b seamless tube be used in Section I construction? TP310HCbN?

Reply: It is the opinion of the Committee that UNS S31042 austenitic stainless steel in the form of ASTM A213/A213M-21b seamless tube may be used in Section I construction, provided the following requirements are met:

(a) This material shall be in accordance with ASTM A213/A213M-21b UNS S31043.

(b) This material shall be used for superheater parts in PG-9.2.

(c) The maximum design temperature is less than or equal to 1,350°F (732°C).

(d) The maximum allowable stress values shall be those for SA-213/SA-213M TP310HCbN (UNS S31042) including applicable notes listed in Section II, Part D, Table 1A.

(e) The physical properties shall be same as those for SA-213/SA-213M TP310HCbN (UNS S31042) listed in Section II, Part D.

(f) The required thickness for external pressure shall be determined from Section II, Part D, Figure HA-2.

(g) Cold forming rules for SA-213/SA-213M TP310HCbN (UNS S31042) in PG-19 shall apply.

(h) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. This material shall be considered P-No. 8 Gr. 3.

(i) All other requirements of Section I shall be met.

(j) This Case number shall be shown in the documentation and on the Manufacturer's Data Report.

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Case 3062

Attaching Tubes to Tubesheets Using GTAW Welding

Section IV

Approval Date: November 29, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may tubes be attached using GTAW welding to a tubesheet that has tube holes that are neither beveled nor recessed and extend through the tubesheet less than the distance required by HLW-413(b)?

Reply: It is the opinion of the Committee that tubes may be attached using GTAW welding (made without weld filler metal) to a tubesheet that has tube holes that are neither beveled nor recessed and extend

through the tubesheet less than the distance required by HLW-413(b), provided the following requirements are met:

(a) Each tube shall pass through the tubesheet, and its end shall extend beyond the tubesheet not less than the tube thickness, nor more than 3 times the sum of the thickness of the head plus the thickness of the tube.

(b) The minimum thickness of the weld shall be no less than the tube thickness. In addition, the welding procedure and the performance qualification shall be performed in accordance with Section IX, QW-193.

(c) All other requirements of Section IV shall be met.

(d) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3063-1

Use of Hot-Isostatically Pressed Pure Isotropic Molybdenum (Class 1 and 2)

Section VIII, Division 1; Section VIII, Division 2

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may isotropic pure molybdenum powdered metal components produced by hot-isostatically pressing (HIP) be used for Section VIII, Division 1 and Section VIII, Division 2, Class 1 and Class 2 construction?

Reply: It is the opinion of the Committee that isotropic pure molybdenum powdered metal components produced by hot-isostatically pressing (HIP) may be used for Section VIII, Division 1 and Section VIII, Division 2, Class 1 and Class 2 construction, provided the following requirements are met:

1 MATERIAL REQUIREMENTS

1.1 REFERENCED DOCUMENTS

- ASTM E8/E8M. Test Methods for Tension Testing of Metallic Materials. ASTM International.
- ASTM E29. Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications. ASTM International.
- ASTM E92. Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials. ASTM International.
- ASTM E399. Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness of Metallic Materials. ASTM International.
- ASTM E1820. Standard Test Method for Measurement of Fracture Toughness. ASTM International.
- ASTM E1941. Test Method for Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis. ASTM International.
- ISO 2768. Dimensional tolerances. International Standards Organization.

1.2 TERMINOLOGY

HIP batch: for chemical composition, the ingots obtained from a single blend of powder, sintered together under the same conditions; for mechanical property measurement, the product manufactured from ingots sintered from a single powder lot in a single sintering run in the same

furnace and hot isostatically pressed in the same hot isostatic press run.

powder batch: for chemical composition, the unit of powder from a single powder blend.

1.3 ORDERING INFORMATION

- (a) product form
- (b) chemical requirements (see [Tables 1 and 2](#))
- (c) metallurgical condition (see [1.6](#))
- (d) mechanical requirements (see [1.7](#))
- (e) tolerances (see [1.9](#))
- (f) workmanship and quality level requirements (see [1.10](#))
- (g) disposition of rejected material (see [1.11](#))
- (h) certification and reports (see [1.12](#))
- (i) marking (see [1.13](#))
- (j) packaging (see [1.14](#))

1.4 MATERIALS AND MANUFACTURE

The molybdenum product covered by this Case shall be manufactured by conventional powder metallurgical processes such as powder compaction, pressing, sintering, and hot-isostatic pressing. Materials and components manufactured to this Case shall be limited to a weight no larger than 5,000 lb (2 300 kg).

1.5 CHEMICAL COMPOSITION

(a) The molybdenum from each sintered batch for conversion to finished products covered by this Case shall conform to the requirements of the chemical composition prescribed in [Table 1](#).

(b) With prior approval of the Manufacturer and User, test specimens may be taken from a separate test sintered ingot. The separate test sintered ingot shall be of the same powder batch and shall be processed simultaneously in the same sintering process conditions for the HIP batch it represents.

(c) *Heat Analysis*

(1) Heat analysis is made by the material manufacturer of the metal on a sintered sample powder from a single powder batch sintered together as representative of the HIP batch it represents.

(2) Heat analysis shall be as specified in [Table 1](#).

(d) Check Analysis

(1) Check analysis is an analysis made by the material manufacturer of the metal after it has been processed into finished mill forms, either for the purpose of verifying the composition of a HIP batch or to determine variations in the composition within a HIP batch.

(2) Check analysis tolerances do not broaden the specified heat analysis requirements but cover variations between laboratories in the measurement of chemical content.

(3) Check analysis limits shall be as specified in [Table 2](#).

(4) In addition to the sampling requirements in Section VIII, Division 1 and Division 2, the following requirements shall also be met.

(-a) Care shall be exercised to ensure that the sample selected for testing is representative of the material and form and is not contaminated by the sampling procedure.

(-b) Analysis may be made using the material manufacturer's standard methods. If there is any question relating to the sampling technique or the analysis of the sample, the methods of sampling and analysis shall be as agreed upon between the User, Manufacturer, and the material manufacturer.

(e) Separate powder batches shall not be mixed.

(f) Chemical traceability to each HIP batch results shall be maintained.

1.6 METALLURGICAL CONDITION

Products shall be delivered in the hot-isostatically pressed condition, and if required, with additional high temperature thermal processing.

1.7 MECHANICAL PROPERTIES

Material from each HIP batch supplied under this Case shall conform to the mechanical property requirements given in [Table 3](#), when tested at temperatures between 65°F and 85°F (18°C and 30°C) in accordance with the following:

(a) Sampling:

(1) Care shall be exercised to ensure that the sample selected for testing is representative of the material and form and is not contaminated by the sampling procedure.

(2) The samples shall be taken from the hot-isostatically pressed product made from a single powder batch consolidated in the same hot-isostatic press using the same pressure, temperature, and time parameters and heat-treated in the same final heat-treatment charge. Samples may be taken prior to final inspection and shall be representative of the finished product. Test reports/certifications shall include mechanical test results.

(3) Components or material weighing up to 5,000 lb (2300 kg) at the time of hot-isostatic pressing require at least one tension test and one fracture toughness test

specimen per HIP ingot. If the HIP ingot, excluding test prolongation(s), exceeds 80 in. (2000 mm), then one set of tests shall be taken at each end, and they shall be spaced 180 deg apart.

(4) In lieu of (3), with prior approval of the Manufacturer and User, test specimens may be taken from a separate test HIP ingot that has simultaneously received the same HIP process conditions for which the tests are being conducted. At least one tension test and one fracture toughness test specimen are required.

(5) Tension test specimens shall be prepared and tested in accordance with ASTM E8/E8M. Tensile properties shall be determined using a strain rate of 0.005 in. to 0.010 in./in.·min (0.13 mm to 0.25 mm/mm·min) for sufficient strain to accurately determine a 0.2% offset yield strength value, and 0.05 in. to 0.1 in./in.·min (1.3 mm to 2.5 mm/mm·min) to fracture.

(b) Traceability. Traceability of all mechanical testing shall be maintained to each HIP batch.

1.8 STRUCTURAL INTEGRITY REQUIREMENTS: MICROPOROSITY

The structural integrity of the components shall be demonstrated by measurement of density as provided in (a) or by microstructural examination as provided in (b). The samples shall be taken after hot-isostatic pressing or after final heat treatment. The samples shall be taken from the hot-isostatically pressed product made from a single powder batch consolidated in the same hot-isostatic press using the same pressure, temperature, and time parameters and heat-treated in the same final heat-treatment charge. With prior approval of the Manufacturer and User, structural integrity may be evaluated from a separate test HIP ingot that has simultaneously received the same HIP process conditions for which the structural integrity is to be conducted.

(a) Density Measurement

(1) The density measurement shall be used for acceptance of material but not for rejection of material. The measured density for each HIP batch shall exceed a density of 0.354 lb/in.³ (9.8 g/cm³). A HIP batch that fails to meet this acceptance criterion is permitted to be tested at the option of the producer, for microporosity in accordance with the microstructural examination as provided in (b).

(2) Density shall be determined for two samples from each HIP batch. For any product 3 in. (80 mm) or greater in diameter or thickness,

(-a) one sample shall be a maximum 1/4 in. (6 mm) from the original surface of the hot-isostatically pressed product, and

(-b) one sample shall be a minimum of 1 in. (25 mm) from the original surface of the hot-isostatically pressed product.

Density shall be determined by measuring the difference in mass of the sample when weighed in air and when weighed in water and multiplying this difference by the density of water (Archimede's principle). The equipment used shall be capable of determining density within 0.003 lb/in.³ (0.08 g/cm³). Alternatively, at the option of the producer, it is permitted to use Test Method B311 to determine the density.

(b) Microstructural Examination

(1) The microstructure shall be examined at 100X to 200X and shall be reasonably uniform and shall be free of laps and cracks.

(2) Two samples from each HIP batch shall be examined.

(-a) One sample shall be a maximum $\frac{1}{4}$ in. (6 mm) from the original surface of the hot-isostatically pressed product, and

(-b) One sample a minimum 1 in. (25 mm) from the original surface of hot-isostatically pressed product for any product 3 in. (76 mm) or greater in diameter or thickness.

The microstructure shall meet the requirements of *(1)*.

(3) If the sample fails to meet the requirements for acceptance, each component in the lot is permitted to be retested and those that pass shall be accepted.

1.9 DIMENSIONS, MASS, AND PERMISSIBLE VARIATIONS

All surfaces of product supplied under this Case shall be furnished in the rough machined condition, with tolerances per ISO 2768.

1.10 WORKMANSHIP, FINISH, AND APPEARANCE

(a) Cracks, seams, slivers, blisters, burrs, and other injurious imperfections shall not exceed standards of acceptability agreed upon by the manufacturer and the vessel manufacturer.

(b) Methods of testing for these defects and standards of acceptability shall be as agreed upon between the manufacturer and the vessel manufacturer.

(c) The manufacturer shall be permitted to remove surface imperfections, provided such removal does not reduce the dimension below the minimum permitted by the tolerance for the dimension specified.

1.11 CERTIFICATION

The material manufacturer shall supply at least one copy of the report certifying that the material supplied has been manufactured, inspected, sampled, and tested in accordance with the requirements of this Case and that the results of chemical analysis, mechanical, and other tests meet the requirements of this Case. The report shall include results of all chemical analysis and mechanical and other tests required by the Case.

The report shall include the purchase order number, powder batch number, HIP batch number, this Case number, quantity, and number of items covered by shipment.

1.12 MATERIAL MARKING

Unless otherwise specified, each piece of material shall be legibly and conspicuously marked or tagged with the Code Case number, HIP batch number, manufacturer's identification, and nominal size.

All markings must withstand ordinary handling and shall be capable of removal with standard cleaning solvents. The marking shall have no deleterious effect on the material or its performance.

1.13 PACKAGING AND PACKAGE MARKING

Unless otherwise specified, material purchased under this Code Case must be packaged by box or other suitable protective containers and should be marked to indicate the nature of any special handling required.

All material shall be packaged in such a manner as to ensure safe delivery to its destination when properly transported by any common carrier. The package shall be marked to indicate the nature of any special handling required. Each package shall be legibly and conspicuously marked or tagged with the following information:

- (a)* purchase order or contract number
- (b)* name of material
- (c)* size
- (d)* lot, heat, or ingot number
- (e)* temper
- (f)* gross, net, and tare weights
- (g)* this Case number

2 GENERAL REQUIREMENTS

(a) A User's Design Specification meeting the requirements of Section VIII, Division 2 shall be required.

(b) The material shall be produced following the material requirements (see section 1) in this Case.

(c) The process fluid is limited to molten tin and nonflammable fluids.

(d) No welding is permitted on this material.

(e) The maximum allowable stress values for Section VIII, Division 1 shall be those given in Table 4 (Table 4M).

(f) The maximum allowable stress values for Section VIII, Division 2, Class 1 shall be those given in Table 5 (Table 5M).

(g) For Section VIII, Division 2, Class 2

(1) The maximum allowable stress values for Section VIII, Division 2, Class 2 shall be those given in Table 11 (Table 11M).

(2) For evaluation of plastic collapse of Section VIII, Division 2, 5.2.4, the true stress-strain curves shall be as found in *(-a)*.

(-a) Ramberg-Osgood Stress-Strain Curve Model

$$n_{RO} = \frac{1}{A_{RO}} \ln \left[\frac{\sigma_{uts}}{\sigma_{ys}} \right]^{B_{RO}} \quad (1)$$

$$H_{RO} = \frac{\sigma_{uts} \exp [n_{RO}]}{n_{RO}^{n_{RO}}} \quad (2)$$

(-1) True Strain can then be calculated with

$$\varepsilon_T = \frac{\sigma_T}{E} + \left(\frac{\sigma_T}{H_{RO}} \right)^{\frac{1}{n_{RO}}} \quad (3)$$

(-2) Calculation of Proportional Limit

(+a) True Stress at Proportional Limit

$$\sigma_{PL} = H_{RO} e^{n_{RO} \ln(\varepsilon_p)} \quad (4)$$

(+b) True Strain at Proportional Limit

$$\varepsilon_{TPL} = \frac{\sigma_{PL}}{E} + \left(\frac{\sigma_{PL}}{H_{RO}} \right)^{\frac{1}{n_{RO}}} \quad (5)$$

(-3) Calculation of True Ultimate Tensile Stress and Strain

(+a) True Tensile Stress

$$\sigma_{uts,T} = \sigma_{uts} \exp [n_{RO}] \quad (6)$$

(+b) True Strain at True Tensile Stress

$$\varepsilon_{uts,T} = \frac{\sigma_{uts,T}}{E} + \left(\frac{\sigma_{uts,T}}{H_{RO}} \right)^{\frac{1}{n_{RO}}} \quad (7)$$

(-4) Nomenclature

- A_{RO} = Ramberg-Osgood curve-fit coefficient
 B_{RO} = Ramberg-Osgood curve-fit exponent
 α_{sl} = material factor for the multiaxial strain limit
 E = elastic modulus
 ε_p = see Table 12
 ε_T = true strain
 ε_{TPL} = true strain at the proportional limit
 $\varepsilon_{uts,T}$ = true tensile strain at the engineering tensile strain
 ε_{ys} = yield offset strain = 0.002
 H_{RO} = constant in Ramberg-Osgood stress-strain curve model
 n_{RO} = material parameter equal to the true strain at the true ultimate stress
 σ_{PL} = true stress at the proportional limit
 σ_T = true stress
 σ_{uts} = engineering tensile stress
 $\sigma_{uts,T}$ = true tensile stress at the engineering tensile stress
 σ_{ys} = engineering yield stress

(3) The values of ε_{Lw} , m_2 , and α_{sl} for evaluation of Section VIII, Division 2, 5.3.3, shall be determined from Table 12.

(h) The maximum design temperature shall be 572°F (300°C).

(i) Yield strength values used in design shall be those given in Table 6 (Table 6M).

(j) Tensile strength values used in design shall be those found in Table 7 (Table 7M).

(k) Physical properties for design shall be those found in Table 8 (Table 8M) for thermal expansion, Table 9 (Table 9M) for thermal conductivity and thermal diffusivity, Table 10 (Table 10M) for moduli of elasticity.

(l) Poisson's ratio for this material shall be 0.29.

(m) Density used in design for this material shall be 0.35 lb/in.³ (9.8 g/cm³).

(n) Establishment of the MDMT Using a Fracture Mechanics Methodology

(1) The MDMT shall be established using a fracture mechanics approach. The fracture mechanics procedures shall be in accordance with API 579-1/ASME FFS-1, Part 9, Level 2 or Level 3.

(2) The assessment used to determine the MDMT shall include a systematic evaluation of all factors that control the susceptibility to brittle fracture, e.g., stresses from the applied loadings including thermal stresses, flaw size, fracture toughness, heat treatment, and the loading rate.

(3) The reference flaw size used in the fracture mechanics evaluation shall be a surface flaw with a depth of $a = \min.[t/4, 25 \text{ mm (1 in.)}]$ and a length of $2c = 6a$ where t is the thickness of the component in the highest stressed region containing the reference flaw. If approved by the user, an alternative reference flaw size may be used based on the NDE that will be used and demonstrated for qualification of the vessel.

(4) The minimum material fracture toughness to be achieved during testing shall be specified in the User's Design Specification.

(5) The fracture toughness of each HIP batch of material shall be tested at or below the MDMT using either J-Integral fracture toughness testing in accordance with ASTM E1820 or using linear elastic plane strain fracture toughness testing, K_{Ic} , in accordance with ASTM E399. Three specimens shall be tested for each HIP batch of material. If the J-Integral method is used, the equivalent K_{Ic} , denoted K_{Jc} , shall be computed using API 579-1/ASME FFS-1, Equation (9F.7.6). The resultant fracture toughness values shall meet the applicable specimen validity requirements specified in either of the respective ASTM testing standards used. If the specimen's thickness validity requirement is not met, then the measured toughness value can be used in the fracture mechanics analysis for vessel minimum thickness not exceeding 1.18 times the specimen thickness. A minimum value of K_{Ic} or K_{Jc}

from the three tested specimens shall be used in fracture mechanics analysis in (n) and (p) of this Code Case.

(o) Fatigue screening is not permitted for Section VIII, Division 2.

(p) The number of design cycles shall be calculated using a fracture mechanics assessment in accordance with Section VIII, Division 3, Article KD-4 in lieu of the fatigue requirements of Section VIII, Division 2. The evaluation for design cycles is made based on the number of applied cycles of a stress or strain range at a point in the component. The allowable number of cycles should be adequate for the specified number of cycles as given in the User's Design Specification.

(1) Fatigue crack growth rate testing shall be conducted in accordance with ASTM E647.

(-a) The purpose of this test is to qualify the construction material by testing three HIP batches of the material per heat treat condition.

(-b) The test specimens shall be in the final heat-treated condition (if applicable) to be used in the vessel construction.

(-c) Three da/dN vs. ΔK data sets shall be generated per test.

(-d) The upper bound data shall be used in the analysis.

(-e) The data in the form of $da/dN = c(\Delta K)^m$ shall be obtained for the full range of ΔK of interest used in the fracture analysis.

(-f) The R-ratio defined as K_{min}/K_{max} shall not be less than that used in the vessel design.

(-g) The data obtained may be used for other vessels manufactured from the same material specification/grade or similar specification/grade having the same nominal chemical composition and heat treatment condition, provided its tensile and yield strengths do not exceed the values of the material used in the qualification tests by more than 5%.

(2) The fracture toughness used in the evaluation shall be based on the fracture toughness specified in the User's Design Specification at the MDMT.

(q) The fracture mechanics calculations for both life and MDMT shall be certified by a Certifying Engineer.

(r) All vessel components shall be non-destructively examined as required in Section VIII, Division 3, Part KE.

(s) This Case number shall be shown on the documentation and marking of the material and recorded on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition (Weight), %
C, max.	0.010
O, max.	0.0070
N, max.	0.0020
Fe, max.	0.010
Ni, max.	0.005
Si, max.	0.010
Mo	balance

Table 2
Permissible Variations in Check Analysis

Element	Check Analysis Limits, Weight % Max. or Range	Permissible Variations in Check Analysis, %
C	0.010	+0.002
O	0.007	+10% relative
N	0.002	+0.0005
Fe	0.010	0.001
Ni	0.005	+10% relative
Si	0.010	+0.002

Table 3
Tensile and Hardness Requirements at Room Temperature

Tensile Strength, min.	65.3 ksi (450 MPa)
Yield Strength (0.2% offset), min	46.4 ksi (320 MPa)
Elongation in 0.8 in. (20 mm), min.	20%
Diamond Pyramid Hardness (DPH), -10 kg, Vickers - 10 kg, min.	150 HV

Table 4
Maximum Allowable Stress Values — Section VIII,
Division 1

Temperature, °F	Maximum Allowable Stress, ksi
72 to 100	18.6
150	17.0
200	15.7
250	14.5
300	12.6
400	11.4
500	11.4
600	11.0

Table 4M
Maximum Allowable Stress Values — Section VIII,
Division 1

Temperature, °C	Maximum Allowable Stress, MPa
20 to 40	129
65	117
100	106
125	97.6
150	86.7
175	81.1
200	78.9
225	78.6
250	78.6
275	78.1
300	76.7

Table 5
Maximum Allowable Stress Values — Section VIII,
Division 2, Class 1

Temperature, °F	Maximum Allowable Stress, ksi
72 to 100	21.8
150	19.8
200	17.5
250	14.5
300	12.6
350	11.7
400	11.4
500	11.4
600 [Note (1)]	11.0

NOTE: (1) The maximum use temperature is 572°F. Values above that are provided only for interpolation purposes.

Table 5M
Maximum Allowable Stress Values — Section VIII,
Division 2, Class 1

Temperature, °C	Maximum Allowable Stress, MPa
20 to 40	150
65	137
100	115
125	97.6
150	86.7
175	81.1
200	78.9
225	78.6
250	78.6
275	78.1
300	76.7

Table 6
Minimum Yield Strength Values for Design, ksi

Temperature, °F	Yield Stress, ksi
72 to 100	46.4
150	32.7
200	26.2
250	21.7
300	19.0
350	17.6
400	17.1
450	17.1
500	17.1
550	16.9
600 [Note (1)]	16.5

NOTE: (1) The maximum use temperature is 572°F. Values above that are provided only for interpolation purposes.

Table 6M
Minimum Yield Strength Values for Design, MPa

Temperature, °C	Yield Stress, MPa
20 to 40	320
65	226
100	172
125	146
150	130
175	122
200	118
225	118
250	118
275	117
300	115

Table 7
Minimum Tensile Strength Values for Design, ksi

Temperature, °F	Tensile Stress, ksi
72 to 100	65.3
150	59.4
200	54.8
250	51.4
300	48.8
350	46.5
400	44.5
500	41.1
600 [Note (1)]	38.6

NOTE: (1) The maximum use temperature is 572°F. Values above that are provided only for interpolation purposes.

Table 7M
Minimum Tensile Strength Values for Design, MPa

Temperature, °C	Tensile Stress, MPa
20 to 40	450
65	411
100	372
125	352
150	336
175	322
200	309
225	297
250	287
275	278
300	270

**Table 8
Thermal Expansion**

Temperature, °F	A [Note (1)]	B [Note (2)]	C [Note (3)]
70	3.0	3.1	0.00
100	2.9	3.0	0.11
150	2.7	2.9	0.28
200	2.5	2.8	0.45
250	2.6	2.8	0.61
300	2.7	2.8	0.78
350	3.0	2.8	0.97
400	3.3	2.9	1.2
450	3.1	2.9	1.3
500	3.0	2.9	1.5
550	3.0	2.9	1.7
600	2.9	2.9	1.9
700	3.0	2.9	2.2
750	2.9	2.9	2.4
800	3.2	3.0	2.6
900	3.7	3.0	3.0
950	3.9	3.0	3.2
1,000	3.8	3.0	3.4

NOTES:

- (1) Coefficient A is the instantaneous coefficient of thermal expansion $\times 10^{-6}$ (in./in./°F).
- (2) Coefficient B is the mean coefficient of thermal expansion $\times 10^{-6}$ (in./in./°F) in going from 70°F to indicated temperature.
- (3) Coefficient C is the linear thermal expansion (in./100 ft) in going from 70°F to indicated temperature.

**Table 8M
Thermal Expansion**

Temperature, °C	A [Note (1)]	B [Note (2)]	C [Note (3)]
20	5.5	5.5	0.00
50	5.1	5.3	0.16
75	4.7	5.2	0.28
100	4.5	5.1	0.40
125	4.7	5.0	0.53
150	5.0	5.0	0.66
175	5.4	5.1	0.79
200	5.8	5.2	0.93
225	5.7	5.2	1.1
250	5.5	5.2	1.2
275	5.4	5.2	1.3
300	5.3	5.2	1.5
325	5.3	5.2	1.6
350	5.5	5.3	1.7
375	5.4	5.3	1.9
400	5.3	5.3	2.0

NOTES:

- (1) Coefficient A is the instantaneous coefficient of thermal expansion $\times 10^{-6}$ (mm/mm/°C).
- (2) Coefficient B is the mean coefficient of thermal expansion $\times 10^{-6}$ (mm/mm/°C) in going from 20°C to indicated temperature.
- (3) Coefficient C is the linear thermal expansion (mm/m) in going from 20°C to indicated temperature.

Table 9
Nominal Coefficients of Thermal Conductivity (TC) and Thermal Diffusivity (TD)

Temperature, °F	Thermal Conductivity (TC), Btu/hr-ft-°F	Thermal Diffusivity (TD), ft ² /hr
70	82.2	2.13
100	78.4	2.10
150	78.2	2.04
200	77.9	1.99
250	76.8	1.95
300	75.7	1.91
350	76.3	1.87
400	76.8	1.84
450	74.9	1.81
500	73.0	1.77
550	72.4	1.75
600	71.7	1.73
650	70.9	1.71
700	70.3	1.68
750	69.9	1.67

GENERAL NOTES:

(a) The following equation applies to this table:

$$TD = \frac{TC[\text{Btu}/(\text{hr} - \text{ft} - ^\circ\text{F})]}{\text{density}\left(\frac{\text{lb}}{\text{ft}^3}\right) \times \text{specific heat}[\text{Btu}/(\text{lb} - ^\circ\text{F})]}$$

(b) Values of thermal conductivity and thermal diffusivity should be used with the understanding that there is an associated $\pm 10\%$ uncertainty. This uncertainty results from compositional variations and variables associated with original data acquisition and analysis.

Table 9M
Nominal Coefficients of Thermal Conductivity (TC) and Thermal Diffusivity (TD)

Temperature, °C	Thermal Conductivity, W/m-°C	Thermal Diffusivity, 10 ⁻⁶ m ² /sec
20	143	55.1
50	136	53.5
75	135	52.3
100	134	51.1
125	133	50.1
150	131	49.2
175	132	48.4
200	133	47.6
225	131	46.8
250	128	46.1
275	126	45.5
300	125	45.0
325	124	44.4
350	122	43.9
375	122	43.4
400	121	43.0
425	120	42.6
450	120	42.1
475	119	41.7
500	118	41.2

GENERAL NOTES:

(a) The following equation applies to this table:

$$TD = \frac{TC[\text{W}/(\text{m} - ^\circ\text{C})]}{\text{density}\left(\frac{\text{kg}}{\text{m}^3}\right) \times \text{specific heat}[\text{J}/(\text{kg} - ^\circ\text{C})]}$$

(b) Values of thermal conductivity and thermal diffusivity should be used with the understanding that there is an associated $\pm 10\%$ uncertainty. This uncertainty results from compositional variations and variables associated with original data acquisition and analysis.

**Table 10
Moduli of Elasticity**

Temperature, °F	Modulus of Elasticity, ksi
72 to 100	43,500
200	43,200
300	42,900
400	42,600
500	42,300
572	42,100

**Table 10M
Moduli of Elasticity**

Temperature, °C	Modulus of Elasticity, GPa
25	300
100	298
150	296
200	294
250	292
300	290

**Table 11
Maximum Allowable Stress Values — Section VIII,
Division 2, Class 2**

Temperature, °F	Maximum Allowable Stress, ksi
72 to 100	27.2
150	21.8
200	17.5
250	14.5
300	12.6
350	11.7
400	11.4
450	11.4
500	11.4
550	11.2
600	11.0

GENERAL NOTE: The maximum use temperature is 572°F. Values above that are provided only for interpolation purposes.

**Table 11M
Maximum Allowable Stress Values — Section VIII,
Division 2, Class 2**

Temperature, °C	Maximum Allowable Stress, ksi
20 to 40	188
65	151
100	115
125	97.6
150	86.7
175	81.1
200	78.9
225	78.6
250	78.6
275	78.1
300	76.7

**Table 12
Stress Strain Curve Parameters and Uniaxial Strain Limit
for Use in Multiaxial Strain Limit Criterion**

Temperature Limit, °F (°C)	$m_2 = \epsilon_{Lu} = n_{RO}$	ϵ_p	α_{sl}	A_{RO}	B_{RO}
572°F (300°C)	0.24 (1.82-R)	2.0 E-5	2.5	3.93	0.754

GENERAL NOTE: R is the engineering yield to engineering tensile strength ratio.

Case 3064

Use of Types 308LSi and 316LSi Weld Filler Metals at MDMT Colder Than -320°F (-196°C)

Section VIII, Division 1

Approval Date: December 21, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In Section VIII, Division 1, Subsection C, Part UHA, may Types 308LSi and 316LSi weld filler metals be used to construct vessels with minimum design metal temperature (MDMT) colder than -320°F (-196°C)?

Reply: It is the opinion of the Committee that Types 308LSi and 316LSi weld filler metals may be used to construct vessels with MDMT colder than -320°F (-196°C) in Section VIII, Division 1, Subsection C, Part UHA, provided the following requirements are met:

(a) For Type 316LSi filler metal, the welding processes shall be limited to flux cored arc welding (FCAW), gas metal arc welding (GMAW), submerged arc welding (SAW), plasma arc welding (PAW), and gas tungsten arc welding (GTAW).

(b) For Type 308LSi filler metal, the welding processes shall be limited to GTAW, FCAW, and GMAW.

(c) Each heat, lot, or batch of filler metal and filler metal/flux combination shall be pre-use tested as required by UHA-51(f)(4)(-a) through UHA-51(f)(4)(-c). Exemption from pre-use testing as allowed by UHA(f)(4)(-d) and UHA(f)(4)(-e) is not applicable.

(d) Weld metal deposited from each heat of Type 316LSi filler metal shall have a Ferrite Number (FN) not greater than 10, and a weld metal deposited from each heat of Type 308LSi filler metal shall have a FN in the range of 4 to 14, as measured by a ferrite scope or magna gauge calibrated in accordance with AWS A4.2, or as determined by applying the chemical composition from the test weld to Figure UHA-51-1.

(e) Impact tests shall be conducted at -320°F (-196°C) on three sets of three specimens: one set from the base metal, one set from the weld metal, and one set from the heat-affected zone (HAZ).

(f) Each of the three specimens from each test set shall have a lateral expansion opposite the notch not less than 0.021 in. (0.53 mm).

(g) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3065

Use of Material Test Report Mechanical Properties to Calculate the MAWP of Vessel or Component by Proof Testing in Accordance With UG-101(m)(2)

Section VIII, Division 1

Approval Date: January 2, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the maximum allowable working pressure (MAWP) of a proof tested component be calculated from the results of a proof test using the tensile strength of the material reported on a material test report?

Reply: It is the opinion of the Committee that the MAWP of a proof tested component may be calculated from the results of a proof test using the tensile strength of the material reported on a material test report when the following requirements are met:

(a) The component is proof tested following the provisions of UG-101(m).

(b) Postweld heat treatment is not applied to the production component.

(c) The tensile strength reported on the material test report for the material is used for the value of $S_{\mu,avg}$ when the applicable material specification only specifies a minimum ultimate tensile strength without a limit on maximum tensile strength.

(d) The MAWP of the proof tested component is calculated using the proof test results by applying the first formula of UG-101(m)(2)(-a).

(e) This Case number shall be reported on the proof test documentation and the Manufacturer's Data Report.

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Case 3066

Use of SA/IS 2062, Grades E250A, E250BR, E250B0, and E250C, Hot-Rolled Medium- and High-Tensile Strength Structural Steel Plates

Section VIII, Division 1

Approval Date: December 7, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may hot-rolled medium- and high-tensile strength structural steel plates, manufactured in accordance with SA/IS 2062, Grades E250A, E250BR, E250B0, and E250C be used in Section VIII, Division 1 construction within the limitations of UCS-6?

Reply: It is the opinion of the Committee that these materials listed in the Inquiry may be used in Section VIII, Division 1 construction, provided the following requirements are met:

(a) All additional requirements of the coversheet for SA/IS 2062 as published in Section II, Part A shall apply.

(b) For the purpose of impact test requirements, these materials shall be considered as a Curve A material in Figure UCS-66.

(c) These plates shall be considered as being P-No. 1, Group No. 1.

(d) The material property data shall be as follows:

(1) For external pressure design, the requirements of Section II, Part D, Figure CS-2 shall apply.

(2) For physical properties, the material shall be considered as a carbon steel.

(3) For maximum allowable stresses, tensile strength and yield strength shall be as published in Section II, Part D.

(e) All other requirements of Section VIII, Division 1 shall apply, considering these materials as Part UCS carbon steel material. The requirements of UCS-6(b) shall apply.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3067

Sizing Pressure Relief Valves for Economizers

Section I

Approval Date: December 12, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For Section I construction, what criteria may be used for determining relieving capacities for pressure relief valves for economizers that may be partially or completely shut off from the boiler, where the fluid discharged is a mix of both liquid and vapor?

Reply: It is the opinion of the Committee that, for Section I construction, capacities for pressure relief valves for economizers where the fluid discharged is a mix of both liquid and vapor (two-phase flow) for nozzle type pressure relief valves whose certified capacities are determined by the coefficient of discharge method may be determined as follows:

(a) For pressures less than 3,200 psia (22 MPa) the rated relieving capacity shall be calculated by multiplying the rated liquid relieving capacity determined in accordance with Section XIII, 9.7.6.4(d) by the appropriate correction factor K_{ec} :

$$W = W_T \times K$$

(U.S. Customary Units)

$$W_T = 2,407 \times A \times \sqrt{(P - P_d)\rho} \times K_{ec}$$

(SI Units)

$$W_T = 5.092 \times A \times \sqrt{(P - P_d)\rho} \times K_{ec}$$

where

- A = nozzle throat area, in.² (mm²)
- K = coefficient of discharge for the design
- K_{ec} = correction factor from [Table 1 \(Table 1M\)](#)
- P = 1.10 × set pressure, psia + 14.7 psia; or set pressure, psia + 3 psia + 14.7 psia, whichever is greater (1.10 × set pressure, MPa + 0.101 MPa; or set pressure, MPa, + 0.020 MPa + 0.101 MPa, whichever is greater)
- P_d = pressure at discharge of the valve, psia (MPa)
- W = rated relieving capacity, lbm/hr (kg/hr)

- W_T = theoretical flow, lbm/hr (kg/hr)
- ρ = density of water at inlet conditions, lbm/ft³ (kg/m³)

(b) For pressures greater than 3,200 psia (22 MPa) the rated relieving capacity shall be calculated by multiplying the capacity determined in accordance with Section XIII, 9.7.6.4(a) by K_{sc} :

$$W = W_T \times K$$

(U.S. Customary Units)

$$W_T = 51.5 \times A \times P \times K_{sc}$$

(SI Units)

$$W_T = 5.25 \times A \times P \times K_{sc}$$

where

- A = nozzle throat area, in.² (mm²)
- K = coefficient of discharge for the design
- K_{sc} = correction factor from [Table 2 \(Table 2M\)](#)
- P = 1.03 × set pressure, psia + 14.7 psia (1.03 × set pressure, MPa + 0.101 MPa)
- W = rated relieving capacity, lbm/hr (kg/hr)
- W_T = theoretical flow, lbm/hr (kg/hr)

(c) A coefficient of discharge, K_d , for two-phase flow can be established for a specific valve design in accordance with Section XIII, 9.7.6. In the absence of such testing, 0.65 shall be used for K_d for two-phase flow. Note that in accordance with Section XIII, 9.7.6.5, the coefficient K_d must be multiplied by 0.90, and this product shall be taken as the coefficient K of that design.

(d) If vapor is generated as the fluid moves through the relief valve, a significant backpressure is generated at the outlet. Safety relief valves (a pressure relief valve characterized by rapid opening or by gradual opening that is generally proportional to the increase in pressure that can be used for compressible or incompressible fluids) shall be used instead of liquid relief valves. In addition, the following apply:

- (1) The safety relief valve shall have a closed bonnet.
- (2) Lifting mechanisms shall be sealed against leakage.

(3) Discharge piping shall be provided with adequate provision for water drainage as well as the steam venting. Mufflers shall not be used.

(4) Cast iron bodies are prohibited.

(5) A balanced valve design that incorporates means of minimizing the effect of back pressure on the operational characteristics (opening pressure, closing pressure, and relieving capacity) may be necessary.

(e) The pressure relief valve shall be marked in accordance with PG-110, except that the capacity shall be calculated in accordance with this Code Case and be indicated as “___lb/hr (kg/h) at ___°F (°C),” and this Case number shall be marked on the pressure relief valve.

(f) This Case number shall be shown on the Master Data Report.

Table 1
Economizer Correction Factor, K_{ec}

Flowing Pressure, psia	T_{sat} , °F	Total Temperature, °F, of Fluid														T_{sat} , °F
		200	225	250	275	300	325	350	375	400	425	450	475	500	525	
30	250.3	1.000	0.845	0.132	...	...	...	...	...	...	...	...	...	...	...	0.129
50	281.0	1.000	0.937	0.755	0.345	...	...	...	...	...	...	...	...	...	...	0.130
75	307.6	1.000	0.963	0.864	0.694	0.359	...	...	...	...	...	...	...	...	...	0.139
100	327.8	1.000	0.974	0.906	0.796	0.615	0.208	...	...	...	...	...	...	...	...	0.148
125	344.3	1.000	0.980	0.929	0.848	0.722	0.502	...	...	...	...	...	...	...	...	0.155
150	358.4	1.000	0.983	0.941	0.879	0.783	0.628	0.326	...	...	...	...	...	...	...	0.162
175	370.8	1.000	0.986	0.950	0.898	0.819	0.698	0.497	...	...	...	...	...	...	...	0.169
200	381.8	1.000	0.988	0.957	0.913	0.847	0.747	0.590	0.280	...	...	...	...	...	...	0.174
225	391.8	1.000	0.989	0.962	0.923	0.865	0.780	0.656	0.438	...	...	...	...	...	...	0.179
250	401.0	1.000	0.990	0.967	0.931	0.880	0.808	0.699	0.526	0.187	...	...	...	...	...	0.184
275	409.5	1.000	0.991	0.969	0.938	0.893	0.827	0.735	0.591	0.318	...	...	...	...	...	0.189
300	417.4	1.000	0.992	0.972	0.944	0.903	0.843	0.762	0.635	0.425	...	...	...	...	...	0.193
325	424.8	1.000	0.992	0.974	0.948	0.910	0.858	0.782	0.672	0.496	...	...	...	...	...	0.197
350	431.8	1.000	0.993	0.976	0.952	0.917	0.870	0.801	0.702	0.548	0.268	...	...	...	...	0.201
375	438.4	1.000	0.993	0.978	0.956	0.924	0.878	0.815	0.725	0.594	0.367	...	...	...	...	0.204
400	444.6	1.000	0.994	0.979	0.958	0.929	0.886	0.830	0.749	0.628	0.435	...	...	...	...	0.207
425	450.6	1.000	0.994	0.980	0.961	0.933	0.894	0.839	0.764	0.657	0.490	0.212	...	...	...	0.211
450	456.3	1.000	0.994	0.981	0.963	0.937	0.901	0.850	0.781	0.684	0.533	0.252	...	...	...	0.214
475	461.8	1.000	0.994	0.982	0.965	0.941	0.906	0.858	0.793	0.703	0.569	0.332	...	...	...	0.217
500	467.0	1.000	0.994	0.983	0.967	0.943	0.911	0.866	0.805	0.721	0.598	0.394	...	...	...	0.219
525	472.1	1.000	0.994	0.984	0.968	0.946	0.915	0.873	0.815	0.737	0.625	0.445	...	...	...	0.222
550	477.0	1.000	0.995	0.984	0.970	0.949	0.920	0.880	0.826	0.753	0.649	0.488	0.230	...	...	0.225
575	481.7	1.000	0.995	0.985	0.971	0.951	0.923	0.886	0.835	0.763	0.665	0.518	0.257	...	...	0.227
600	486.2	1.000	0.995	0.986	0.972	0.953	0.927	0.891	0.842	0.777	0.686	0.551	0.320	...	...	0.230
625	490.7	1.000	0.995	0.986	0.973	0.955	0.929	0.895	0.848	0.786	0.700	0.574	0.374	...	...	0.232
650	494.9	1.000	0.995	0.986	0.974	0.956	0.932	0.900	0.856	0.795	0.714	0.596	0.419	...	...	0.234
675	499.1	1.000	0.995	0.987	0.975	0.958	0.935	0.904	0.862	0.804	0.726	0.616	0.455	...	...	0.237
700	503.1	1.000	0.995	0.987	0.976	0.960	0.937	0.908	0.868	0.812	0.739	0.635	0.486	0.247	...	0.239
725	507.1	1.000	0.995	0.988	0.977	0.961	0.939	0.910	0.871	0.820	0.750	0.652	0.511	0.266	...	0.241
750	510.9	1.000	0.995	0.988	0.977	0.962	0.942	0.914	0.876	0.827	0.761	0.668	0.533	0.310	...	0.243
775	514.6	1.000	0.995	0.988	0.978	0.963	0.944	0.917	0.881	0.832	0.768	0.684	0.557	0.352	...	0.245
800	518.3	1.000	0.995	0.988	0.979	0.965	0.945	0.919	0.884	0.839	0.777	0.693	0.576	0.392	...	0.247
825	521.8	1.000	0.995	0.989	0.979	0.965	0.947	0.922	0.889	0.843	0.784	0.707	0.594	0.421	...	0.249
850	525.3	1.000	0.995	0.989	0.980	0.967	0.948	0.924	0.891	0.849	0.793	0.716	0.608	0.454	0.251	0.251
875	528.7	1.000	0.995	0.989	0.980	0.967	0.950	0.927	0.896	0.853	0.798	0.724	0.627	0.475	0.261	0.252
900	532.0	1.000	0.995	0.989	0.980	0.968	0.951	0.928	0.898	0.858	0.804	0.736	0.639	0.498	0.275	0.254
925	535.3	1.000	0.995	0.990	0.981	0.969	0.953	0.930	0.901	0.863	0.812	0.744	0.650	0.523	0.297	0.256
950	538.5	1.000	0.995	0.990	0.981	0.970	0.954	0.932	0.903	0.866	0.817	0.751	0.663	0.540	0.333	0.258
975	541.6	1.000	0.995	0.990	0.982	0.970	0.955	0.933	0.906	0.870	0.822	0.758	0.677	0.556	0.365	0.259
1,000	544.7	1.000	0.995	0.990	0.982	0.971	0.956	0.935	0.908	0.873	0.827	0.765	0.687	0.571	0.394	0.261
1,050	550.6	1.000	0.995	0.990	0.983	0.972	0.958	0.938	0.913	0.880	0.836	0.778	...	...	...	...
1,100	556.4	1.000	0.995	0.990	0.983	0.973	0.960	0.941	0.917	0.886	0.845	0.791	...	...	...	...
1,150	561.9	1.000	0.995	0.991	0.984	0.974	0.961	0.944	0.921	0.890	0.851	0.802	...	...	...	...
1,200	567.3	1.000	0.995	0.991	0.984	0.975	0.963	0.946	0.924	0.895	0.858	0.810	...	...	...	...
1,250	572.5	1.000	0.995	0.991	0.985	0.976	0.964	0.948	0.927	0.899	0.864	0.820	...	...	...	...
1,300	577.5	1.000	0.995	0.991	0.985	0.977	0.965	0.950	0.930	0.903	0.871	0.827	...	...	...	...
1,350	582.4	1.000	0.995	0.991	0.985	0.977	0.966	0.952	0.932	0.908	0.876	0.834	...	...	...	...
1,400	587.1	1.000	0.995	0.991	0.986	0.978	0.967	0.953	0.935	0.911	0.880	0.840	...	...	...	...
1,450	591.8	1.000	0.995	0.991	0.986	0.978	0.968	0.955	0.937	0.913	0.884	0.847	...	...	...	...
1,500	596.3	1.000	0.995	0.991	0.986	0.979	0.969	0.956	0.939	0.916	0.888	0.852	...	...	...	...

Table 1
Economizer Correction Factor, K_{ec} (Cont'd)

Flowing Pressure, psia	T_{sat} , °F	Total Temperature, °F, of Fluid														T_{sat} , °F $X = 0$
		200	225	250	275	300	325	350	375	400	425	450	475	500	525	
1,550	600.7	1.000	0.995	0.992	0.986	0.979	0.970	0.957	0.940	0.919	0.892	0.856	...	...	...	...
1,600	604.9	1.000	0.995	0.991	0.987	0.980	0.971	0.958	0.942	0.922	0.896	0.862	...	...	...	...
1,650	609.1	1.000	0.995	0.992	0.987	0.980	0.971	0.959	0.943	0.924	0.898	0.866	...	...	...	...
1,700	613.2	1.000	0.995	0.992	0.987	0.980	0.972	0.960	0.945	0.926	0.902	0.870	...	...	...	...
1,750	617.2	1.000	0.995	0.992	0.987	0.981	0.972	0.961	0.946	0.928	0.904	0.873	...	...	...	...
1,800	621.1	1.000	0.995	0.992	0.987	0.981	0.973	0.962	0.948	0.930	0.906	0.878	...	...	...	...
1,850	624.9	1.000	0.995	0.992	0.987	0.981	0.973	0.963	0.949	0.932	0.909	0.881	...	...	...	...
1,900	628.6	1.000	0.994	0.992	0.987	0.982	0.974	0.964	0.950	0.933	0.912	0.884	...	...	...	...
1,950	632.3	1.000	0.994	0.992	0.988	0.982	0.974	0.964	0.951	0.935	0.914	0.886	...	...	...	...
2,000	635.9	1.000	0.994	0.992	0.988	0.982	0.975	0.965	0.952	0.936	0.915	0.890	...	...	...	...
2,050	639.4	1.000	0.994	0.992	0.988	0.982	0.975	0.966	0.953	0.938	0.917	0.893	...	...	...	...
2,100	642.8	1.000	0.994	0.992	0.988	0.983	0.976	0.966	0.954	0.939	0.919	0.895	...	...	...	...
2,150	646.2	1.000	0.994	0.992	0.988	0.983	0.976	0.967	0.955	0.940	0.921	0.898	...	...	...	...
2,200	649.5	1.000	0.994	0.991	0.988	0.983	0.976	0.967	0.956	0.941	0.923	0.900	...	...	...	...
2,250	652.7	1.000	0.994	0.991	0.988	0.983	0.977	0.968	0.957	0.942	0.924	0.901	...	...	...	...
2,300	655.9	1.000	0.994	0.991	0.988	0.983	0.977	0.968	0.957	0.944	0.926	0.903	...	...	...	...
2,350	659.1	1.000	0.994	0.991	0.988	0.983	0.977	0.969	0.958	0.945	0.928	0.906	...	...	...	...
2,400	662.2	1.000	0.994	0.991	0.988	0.984	0.977	0.969	0.959	0.945	0.928	0.908	...	...	...	...
2,450	665.2	1.000	0.994	0.991	0.988	0.983	0.978	0.970	0.959	0.946	0.930	0.910	...	...	...	...
2,500	668.2	1.000	0.993	0.991	0.988	0.984	0.978	0.970	0.960	0.947	0.931	0.911	...	...	...	...
2,550	671.1	1.000	0.993	0.991	0.988	0.984	0.978	0.970	0.961	0.948	0.933	0.913	...	...	...	...
2,600	674.0	1.000	0.993	0.991	0.988	0.984	0.978	0.971	0.961	0.949	0.933	0.914	...	...	...	...
2,650	676.8	1.000	0.993	0.991	0.988	0.984	0.978	0.971	0.962	0.950	0.935	0.915	...	...	...	...
2,700	679.6	1.000	0.993	0.991	0.988	0.984	0.979	0.971	0.962	0.950	0.935	0.917	...	...	...	...
2,750	682.3	1.000	0.993	0.991	0.988	0.984	0.979	0.972	0.962	0.951	0.936	0.918	...	...	...	...
2,800	685.0	1.000	0.993	0.991	0.988	0.984	0.979	0.972	0.963	0.951	0.937	0.920	...	...	...	...
2,850	687.7	1.000	0.993	0.991	0.988	0.984	0.979	0.972	0.963	0.952	0.938	0.920	...	...	...	...
2,900	690.3	1.000	0.993	0.991	0.988	0.984	0.979	0.972	0.964	0.953	0.939	0.922	...	...	...	...
2,950	692.9	1.000	0.993	0.991	0.988	0.984	0.979	0.973	0.964	0.953	0.940	0.923	...	...	...	...
3,000	695.4	1.000	0.993	0.991	0.988	0.984	0.979	0.973	0.964	0.954	0.940	0.924	...	...	...	...
3,150	697.9	1.000	0.992	0.991	0.988	0.984	0.979	0.973	0.965	0.954	0.942	0.925	...	...	...	...
3,200	700.3	1.000	0.992	0.990	0.988	0.984	0.979	0.973	0.965	0.955	0.942	0.926	...	...	...	...

GENERAL NOTE: T_{sat} is steam saturation temperature at flowing pressure, for reference. X is the saturated steam dryness fraction ($X = 0$ is 0% vapor, 100% liquid).

Table 1M
Economizer Correction Factor, K_{ec}

Flowing Pressure, MPa	T_{sat} , °C	Total Temperature, °C, of Fluid														T_{sat} , X = 0
		100	115	130	145	160	175	190	205	220	235	250	265	280	295	
0.25	127.4	1.000	0.737	...	...	...	...	...	...	...	...	...	...	...	...	0.128
0.50	151.8	1.000	0.910	0.754	0.450	...	...	...	...	...	...	...	...	...	...	0.138
0.75	167.8	1.000	0.945	0.859	0.718	0.446	...	...	...	...	...	...	...	...	...	0.150
1.00	179.9	1.000	0.961	0.901	0.803	0.650	0.345	...	...	...	...	...	...	...	...	0.161
1.25	189.8	1.000	0.969	0.922	0.850	0.741	0.551	...	...	...	...	...	...	...	...	0.170
1.50	198.3	1.000	0.974	0.937	0.880	0.792	0.657	0.416	...	...	...	...	...	...	...	0.178
1.75	205.7	1.000	0.979	0.946	0.898	0.829	0.718	0.544	0.189	...	...	...	...	...	...	0.185
2.00	212.4	1.000	0.981	0.954	0.913	0.852	0.763	0.626	0.378	...	...	...	...	...	...	0.191
2.25	218.4	1.000	0.983	0.959	0.923	0.871	0.793	0.678	0.493	...	...	...	...	...	...	0.197
2.50	224.0	1.000	0.985	0.963	0.932	0.885	0.818	0.721	0.564	0.275	...	...	...	...	...	0.202
2.75	229.1	1.000	0.986	0.966	0.938	0.897	0.835	0.749	0.621	0.396	...	...	...	...	...	0.207
3.00	233.9	1.000	0.987	0.969	0.943	0.906	0.851	0.774	0.663	0.480	...	...	...	...	...	0.212
3.25	238.3	1.000	0.988	0.972	0.948	0.913	0.865	0.796	0.693	0.545	0.247	...	...	...	...	0.216
3.50	242.6	1.000	0.989	0.974	0.952	0.920	0.875	0.813	0.721	0.591	0.357	...	...	...	...	0.220
3.75	246.6	1.000	0.989	0.975	0.955	0.926	0.883	0.826	0.745	0.624	0.433	...	...	...	...	0.224
4.00	250.4	1.000	0.990	0.977	0.957	0.930	0.893	0.837	0.763	0.654	0.488	0.229	...	...	...	0.228
4.25	254.0	1.000	0.990	0.978	0.960	0.935	0.898	0.848	0.780	0.681	0.534	0.263	...	...	...	0.231
4.50	257.4	1.000	0.991	0.979	0.962	0.938	0.905	0.858	0.795	0.705	0.574	0.348	...	...	...	0.235
4.75	260.8	1.000	0.991	0.980	0.964	0.942	0.909	0.866	0.807	0.722	0.602	0.406	...	...	...	0.238
5.00	263.9	1.000	0.991	0.981	0.966	0.945	0.915	0.873	0.817	0.738	0.628	0.454	...	...	...	0.241
5.25	267.0	1.000	0.992	0.982	0.967	0.947	0.918	0.879	0.827	0.753	0.652	0.496	0.253	...	...	0.244
5.50	270.0	1.000	0.992	0.982	0.969	0.949	0.922	0.886	0.836	0.767	0.673	0.532	0.283	...	...	0.247
5.75	272.8	1.000	0.992	0.983	0.970	0.952	0.926	0.892	0.843	0.780	0.691	0.563	0.347	...	...	0.249
6.00	275.6	1.000	0.992	0.984	0.971	0.953	0.929	0.896	0.851	0.790	0.707	0.587	0.392	...	...	0.252
6.25	278.3	1.000	0.992	0.984	0.972	0.955	0.932	0.900	0.857	0.801	0.720	0.607	0.438	...	...	0.255
6.50	280.9	1.000	0.993	0.985	0.973	0.957	0.935	0.905	0.863	0.809	0.733	0.631	0.475	0.260	...	0.257
6.75	283.4	1.000	0.993	0.985	0.974	0.958	0.937	0.908	0.868	0.817	0.747	0.650	0.504	0.275	...	0.259
7.00	285.8	1.000	0.993	0.985	0.975	0.960	0.939	0.912	0.873	0.824	0.758	0.666	0.531	0.300	...	0.262
7.25	288.2	1.000	0.993	0.986	0.975	0.961	0.942	0.915	0.878	0.831	0.765	0.677	0.556	0.346	...	0.264
7.50	290.5	1.000	0.993	0.986	0.976	0.962	0.943	0.917	0.883	0.836	0.775	0.691	0.572	0.388	...	0.266
7.75	292.8	1.000	0.993	0.986	0.977	0.963	0.945	0.920	0.887	0.842	0.784	0.705	0.592	0.420	...	0.268
8.00	295.0	1.000	0.993	0.987	0.977	0.964	0.947	0.923	0.890	0.849	0.790	0.718	0.612	0.452	0.271	0.271
8.25	297.2	1.000	0.993	0.987	0.978	0.965	0.948	0.925	0.894	0.852	0.799	0.726	0.625	0.478	0.280	0.273
8.50	299.3	1.000	0.993	0.987	0.978	0.966	0.950	0.926	0.897	0.858	0.804	0.738	0.643	0.503	0.293	0.275
8.75	301.3	1.000	0.993	0.987	0.979	0.967	0.951	0.929	0.901	0.862	0.812	0.745	0.654	0.521	0.312	0.277
9.00	303.3	1.000	0.993	0.987	0.979	0.968	0.952	0.931	0.903	0.865	0.817	0.752	0.665	0.546	0.343	0.279
9.25	305.3	1.000	0.993	0.988	0.980	0.969	0.953	0.932	0.905	0.871	0.822	0.761	0.680	0.562	0.376	0.280
9.50	307.3	1.000	0.993	0.988	0.980	0.969	0.955	0.935	0.908	0.874	0.829	0.769	0.689	0.577	0.405	0.282
9.75	309.1	1.000	0.993	0.988	0.980	0.970	0.956	0.936	0.910	0.877	0.834	0.776	0.698	0.591	0.432	0.284
10.00	311.0	1.000	0.993	0.988	0.981	0.970	0.956	0.938	0.913	0.880	0.838	...	...	...	...	...
10.25	312.8	1.000	0.993	0.988	0.981	0.971	0.957	0.939	0.915	0.883	0.842	...	...	...	...	...
10.50	314.6	1.000	0.993	0.988	0.981	0.972	0.958	0.940	0.917	0.886	0.846	...	...	...	...	...
10.75	316.4	1.000	0.993	0.989	0.982	0.972	0.959	0.942	0.919	0.889	0.850	...	...	...	...	...
11.00	318.1	1.000	0.993	0.989	0.982	0.973	0.960	0.943	0.920	0.891	0.854	...	...	...	...	...
11.25	319.8	1.000	0.993	0.989	0.982	0.973	0.961	0.944	0.922	0.894	0.858	...	...	...	...	...
11.50	321.4	1.000	0.993	0.989	0.982	0.973	0.961	0.945	0.924	0.897	0.859	...	...	...	...	...
11.75	323.1	1.000	0.993	0.989	0.983	0.974	0.962	0.946	0.925	0.898	0.863	...	...	...	...	...
12.00	324.7	1.000	0.993	0.989	0.983	0.974	0.963	0.947	0.927	0.900	0.866	...	...	...	...	...
12.25	326.3	1.000	0.993	0.989	0.983	0.975	0.963	0.948	0.928	0.903	0.870	...	...	...	...	...
12.50	327.8	1.000	0.993	0.989	0.983	0.975	0.964	0.949	0.929	0.904	0.871	...	...	...	...	...

Table 1M
Economizer Correction Factor, K_{ec} (Cont'd)

Flowing Pressure, MPa	T_{sat} , °C	Total Temperature, °C, of Fluid														T_{sat} , °C $X = 0$
		100	115	130	145	160	175	190	205	220	235	250	265	280	295	
12.75	329.3	1.000	0.993	0.989	0.983	0.975	0.964	0.950	0.931	0.906	0.874	...	...	...	...	...
13.00	330.9	1.000	0.993	0.989	0.983	0.976	0.965	0.950	0.932	0.908	0.877	...	...	...	...	...
13.25	332.3	1.000	0.993	0.989	0.984	0.976	0.965	0.951	0.933	0.909	0.879	...	...	...	...	...
13.50	333.8	1.000	0.993	0.989	0.984	0.976	0.966	0.952	0.934	0.911	0.882	...	...	...	...	...
13.75	335.2	1.000	0.993	0.989	0.984	0.976	0.966	0.953	0.935	0.912	0.883	...	...	...	...	...
14.00	336.7	1.000	0.993	0.989	0.984	0.977	0.967	0.954	0.936	0.914	0.886	...	...	...	...	...
14.25	338.1	1.000	0.993	0.989	0.984	0.977	0.967	0.954	0.937	0.915	0.887	...	...	...	...	...
14.50	339.5	1.000	0.993	0.989	0.984	0.977	0.968	0.955	0.938	0.917	0.890	...	...	...	...	...
14.75	340.8	1.000	0.993	0.989	0.984	0.977	0.968	0.956	0.939	0.918	0.891	...	...	...	...	...
15.00	342.2	1.000	0.993	0.989	0.984	0.978	0.968	0.956	0.940	0.920	0.894	...	...	...	...	...
15.25	343.5	1.000	0.993	0.989	0.984	0.978	0.969	0.957	0.941	0.921	0.895	...	...	...	...	...
15.50	344.8	1.000	0.993	0.989	0.985	0.978	0.969	0.957	0.942	0.921	0.896	...	...	...	...	...
15.75	346.1	1.000	0.993	0.989	0.985	0.978	0.969	0.958	0.942	0.923	0.898	...	...	...	...	...
16.00	347.4	1.000	0.993	0.989	0.985	0.978	0.970	0.958	0.944	0.924	0.900	...	...	...	...	...
16.25	348.6	1.000	0.993	0.989	0.985	0.979	0.970	0.959	0.944	0.925	0.901	...	...	...	...	...
16.50	349.9	1.000	0.993	0.989	0.985	0.979	0.970	0.959	0.945	0.926	0.903	...	...	...	...	...
16.75	351.1	1.000	0.992	0.989	0.985	0.979	0.971	0.960	0.945	0.927	0.904	...	...	...	...	...
17.00	352.3	1.000	0.992	0.989	0.985	0.979	0.971	0.960	0.946	0.928	0.905	...	...	...	...	...
17.25	353.5	1.000	0.992	0.989	0.985	0.979	0.971	0.960	0.947	0.929	0.906	...	...	...	...	...
17.50	354.7	1.000	0.992	0.989	0.985	0.979	0.971	0.961	0.947	0.930	0.908	...	...	...	...	...
17.75	355.8	1.000	0.992	0.989	0.985	0.979	0.971	0.961	0.948	0.931	0.909	...	...	...	...	...
18.00	357.0	1.000	0.992	0.989	0.985	0.980	0.972	0.962	0.948	0.932	0.910	...	...	...	...	...
18.25	358.1	1.000	0.992	0.989	0.985	0.980	0.972	0.962	0.949	0.932	0.911	...	...	...	...	...
18.50	359.3	1.000	0.992	0.989	0.985	0.980	0.972	0.962	0.950	0.933	0.912	...	...	...	...	...
18.75	360.4	1.000	0.992	0.989	0.985	0.980	0.972	0.963	0.950	0.933	0.913	...	...	...	...	...
19.00	361.5	1.000	0.992	0.989	0.985	0.980	0.973	0.963	0.950	0.935	0.915	...	...	...	...	...
19.25	362.6	1.000	0.992	0.989	0.985	0.980	0.973	0.963	0.951	0.935	0.916	...	...	...	...	...
19.50	363.6	1.000	0.992	0.989	0.985	0.980	0.973	0.963	0.951	0.936	0.916	...	...	...	...	...
19.75	364.7	1.000	0.992	0.989	0.985	0.980	0.973	0.964	0.952	0.937	0.917	...	...	...	...	...
20.00	365.7	1.000	0.992	0.989	0.985	0.980	0.973	0.964	0.952	0.937	0.918	...	...	...	...	...
20.25	366.8	1.000	0.992	0.989	0.985	0.980	0.973	0.964	0.953	0.938	0.919	...	...	...	...	...
20.50	367.8	1.000	0.992	0.989	0.985	0.980	0.973	0.965	0.953	0.938	0.920	...	...	...	...	...
20.75	368.8	1.000	0.992	0.989	0.985	0.981	0.974	0.965	0.953	0.939	0.921	...	...	...	...	...
21.00	369.8	1.000	0.992	0.989	0.985	0.981	0.974	0.965	0.954	0.939	0.921	...	...	...	...	...
21.25	370.8	1.000	0.991	0.989	0.985	0.981	0.974	0.966	0.954	0.940	0.922	...	...	...	...	...
21.50	371.8	1.000	0.991	0.989	0.985	0.981	0.974	0.966	0.954	0.941	0.923	...	...	...	...	...
21.75	372.8	1.000	0.991	0.989	0.985	0.981	0.974	0.966	0.955	0.941	0.924	...	...	...	...	...
22.00	373.7	1.000	0.991	0.989	0.985	0.981	0.974	0.966	0.955	0.942	0.924	...	...	...	...	...

GENERAL NOTE: T_{sat} is steam saturation temperature at flowing pressure, for reference. X is the saturated steam dryness fraction ($X = 0$ is 0% vapor, 100% liquid).

Table 2
Supercritical Correction Factor, K_{sc}

Flowing Pressure, psia	Total Temperature, °F, of Supercritical Steam													
	750	800	850	900	950	1,000	1,050	1,100	1,150	1,200	1,250	1,300	1,350	1,400
200	0.827	0.809	0.792	0.776	0.761	0.747	0.733	0.720	0.708	0.697	0.686	0.675	0.665	0.655
250	0.829	0.811	0.793	0.777	0.762	0.747	0.734	0.721	0.709	0.697	0.686	0.675	0.665	0.656
300	0.831	0.812	0.795	0.778	0.763	0.748	0.734	0.722	0.709	0.698	0.686	0.676	0.666	0.656
350	0.833	0.814	0.796	0.779	0.764	0.749	0.735	0.722	0.710	0.698	0.687	0.676	0.666	0.656
400	0.835	0.815	0.797	0.780	0.765	0.750	0.736	0.723	0.710	0.698	0.687	0.677	0.666	0.657
450	0.837	0.817	0.799	0.782	0.766	0.751	0.737	0.723	0.711	0.699	0.688	0.677	0.667	0.657
500	0.839	0.819	0.800	0.783	0.767	0.752	0.737	0.724	0.711	0.699	0.688	0.677	0.667	0.657
550	0.841	0.821	0.802	0.784	0.768	0.752	0.738	0.725	0.712	0.700	0.688	0.678	0.667	0.657
600	0.843	0.822	0.803	0.785	0.769	0.753	0.739	0.725	0.713	0.700	0.689	0.678	0.668	0.658
650	0.845	0.824	0.804	0.786	0.770	0.754	0.740	0.726	0.713	0.701	0.689	0.678	0.668	0.658
700	0.848	0.826	0.806	0.788	0.771	0.755	0.740	0.727	0.714	0.701	0.690	0.679	0.668	0.658
750	0.850	0.828	0.807	0.789	0.772	0.756	0.741	0.727	0.714	0.702	0.690	0.679	0.669	0.659
800	0.852	0.829	0.809	0.790	0.773	0.757	0.742	0.728	0.715	0.702	0.691	0.679	0.669	0.659
850	0.854	0.831	0.810	0.791	0.774	0.758	0.743	0.729	0.715	0.703	0.691	0.680	0.669	0.659
900	0.857	0.833	0.812	0.793	0.775	0.759	0.743	0.729	0.716	0.703	0.691	0.680	0.670	0.659
950	0.859	0.835	0.814	0.794	0.776	0.760	0.744	0.730	0.716	0.704	0.692	0.681	0.670	0.660
1,000	0.862	0.837	0.815	0.795	0.777	0.760	0.745	0.731	0.717	0.704	0.692	0.681	0.670	0.660
1,050	0.864	0.839	0.817	0.797	0.778	0.761	0.746	0.731	0.718	0.705	0.693	0.681	0.671	0.660
1,100	0.867	0.841	0.818	0.798	0.779	0.762	0.747	0.732	0.718	0.705	0.693	0.682	0.671	0.661
1,150	0.869	0.843	0.820	0.799	0.781	0.763	0.747	0.733	0.719	0.706	0.694	0.682	0.671	0.661
1,200	0.872	0.845	0.822	0.801	0.782	0.764	0.748	0.733	0.719	0.706	0.694	0.683	0.672	0.661
1,250	0.875	0.847	0.823	0.802	0.783	0.765	0.749	0.734	0.720	0.707	0.695	0.683	0.672	0.661
1,300	0.877	0.849	0.825	0.803	0.784	0.766	0.750	0.735	0.721	0.707	0.695	0.683	0.672	0.662
1,350	0.880	0.852	0.827	0.805	0.785	0.767	0.751	0.735	0.721	0.708	0.695	0.684	0.673	0.662
1,400	0.883	0.854	0.829	0.806	0.786	0.768	0.751	0.736	0.722	0.708	0.696	0.684	0.673	0.662
1,450	0.886	0.856	0.830	0.808	0.787	0.769	0.752	0.737	0.722	0.709	0.696	0.684	0.673	0.663
1,500	0.889	0.858	0.832	0.809	0.789	0.770	0.753	0.737	0.723	0.709	0.697	0.685	0.674	0.663
1,550	0.892	0.861	0.834	0.811	0.790	0.771	0.754	0.738	0.724	0.710	0.697	0.685	0.674	0.663
1,600	0.895	0.863	0.836	0.812	0.791	0.772	0.755	0.739	0.724	0.710	0.698	0.686	0.674	0.664
1,650	0.899	0.866	0.838	0.814	0.792	0.773	0.756	0.740	0.725	0.711	0.698	0.686	0.675	0.664
1,700	0.902	0.868	0.840	0.815	0.794	0.774	0.757	0.740	0.725	0.712	0.699	0.686	0.675	0.664
1,750	0.905	0.870	0.842	0.817	0.795	0.775	0.757	0.741	0.726	0.712	0.699	0.687	0.675	0.664
1,800	0.909	0.873	0.844	0.818	0.796	0.776	0.758	0.742	0.727	0.713	0.700	0.687	0.676	0.665
1,850	0.912	0.876	0.845	0.820	0.797	0.777	0.759	0.743	0.727	0.713	0.700	0.688	0.676	0.665
1,900	0.916	0.878	0.848	0.821	0.799	0.778	0.760	0.743	0.728	0.714	0.700	0.688	0.676	0.665
1,950	0.920	0.881	0.850	0.823	0.800	0.779	0.761	0.744	0.729	0.714	0.701	0.688	0.677	0.666
2,000	0.924	0.884	0.852	0.825	0.801	0.780	0.762	0.745	0.729	0.715	0.701	0.689	0.677	0.666
2,050	0.928	0.886	0.854	0.826	0.803	0.782	0.763	0.746	0.730	0.715	0.702	0.689	0.677	0.666
2,100	0.932	0.889	0.856	0.828	0.804	0.783	0.764	0.746	0.730	0.716	0.702	0.690	0.678	0.667
2,150	0.936	0.892	0.858	0.830	0.805	0.784	0.764	0.747	0.731	0.716	0.703	0.690	0.678	0.667
2,200	0.940	0.895	0.860	0.831	0.807	0.785	0.765	0.748	0.732	0.717	0.703	0.690	0.679	0.667
2,250	0.945	0.898	0.863	0.833	0.808	0.786	0.766	0.749	0.732	0.718	0.704	0.691	0.679	0.668
2,300	0.949	0.901	0.865	0.835	0.809	0.787	0.767	0.749	0.733	0.718	0.704	0.691	0.679	0.668
2,350	0.954	0.905	0.867	0.837	0.811	0.788	0.768	0.750	0.734	0.719	0.705	0.692	0.680	0.668
2,400	0.959	0.908	0.869	0.838	0.812	0.789	0.769	0.751	0.734	0.719	0.705	0.692	0.680	0.669
2,450	0.964	0.911	0.872	0.840	0.814	0.790	0.770	0.752	0.735	0.720	0.706	0.693	0.680	0.669
2,500	0.969	0.915	0.874	0.842	0.815	0.792	0.771	0.753	0.736	0.720	0.706	0.693	0.681	0.669

Table 2
Supercritical Correction Factor, K_{sc} (Cont'd)

Flowing Pressure, psia	Total Temperature, °F, of Supercritical Steam													
	750	800	850	900	950	1,000	1,050	1,100	1,150	1,200	1,250	1,300	1,350	1,400
2,550	0.974	0.918	0.877	0.844	0.816	0.793	0.772	0.753	0.736	0.721	0.707	0.693	0.681	0.669
2,600	0.980	0.922	0.879	0.846	0.818	0.794	0.773	0.754	0.737	0.722	0.707	0.694	0.681	0.670
2,650	0.986	0.925	0.882	0.848	0.819	0.795	0.774	0.755	0.738	0.722	0.708	0.694	0.682	0.670
2,700	0.992	0.929	0.884	0.850	0.821	0.796	0.775	0.756	0.738	0.723	0.708	0.695	0.682	0.670
2,750	0.998	0.933	0.887	0.852	0.822	0.798	0.776	0.757	0.739	0.723	0.709	0.695	0.683	0.671
2,800	1.004	0.937	0.890	0.854	0.824	0.799	0.777	0.757	0.740	0.724	0.709	0.696	0.683	0.671
2,850	1.011	0.940	0.892	0.856	0.826	0.800	0.778	0.758	0.741	0.724	0.710	0.696	0.683	0.671
2,900	1.018	0.945	0.895	0.858	0.827	0.801	0.779	0.759	0.741	0.725	0.710	0.696	0.684	0.672
2,950	1.025	0.949	0.898	0.860	0.829	0.803	0.780	0.760	0.742	0.726	0.711	0.697	0.684	0.672
3,000	1.032	0.953	0.901	0.862	0.830	0.804	0.781	0.761	0.743	0.726	0.711	0.697	0.684	0.672
3,050	1.038	0.957	0.904	0.864	0.832	0.805	0.782	0.762	0.743	0.727	0.712	0.698	0.685	0.673
3,100	1.044	0.962	0.907	0.866	0.833	0.806	0.783	0.762	0.744	0.727	0.712	0.698	0.685	0.673
3,150	1.051	0.967	0.910	0.868	0.835	0.808	0.784	0.763	0.745	0.728	0.713	0.699	0.686	0.673

Table 2M
Supercritical Correction Factor, K_{sc}

Flowing Pressure, MPa	Total Temperature, °C, of Supercritical Steam										
	400	425	450	475	500	525	550	575	600	625	650
1.25	0.826	0.809	0.794	0.779	0.766	0.753	0.740	0.728	0.717	0.706	0.696
1.50	0.827	0.811	0.795	0.780	0.766	0.753	0.741	0.729	0.718	0.707	0.696
1.75	0.829	0.812	0.796	0.781	0.767	0.754	0.741	0.729	0.718	0.707	0.697
2.00	0.830	0.813	0.797	0.782	0.768	0.755	0.742	0.730	0.718	0.707	0.697
2.25	0.831	0.814	0.798	0.783	0.769	0.755	0.742	0.730	0.719	0.708	0.697
2.50	0.833	0.815	0.799	0.784	0.769	0.756	0.743	0.731	0.719	0.708	0.698
2.75	0.834	0.817	0.800	0.785	0.770	0.757	0.744	0.731	0.720	0.709	0.698
3.00	0.836	0.818	0.801	0.786	0.771	0.757	0.744	0.732	0.720	0.709	0.698
3.25	0.837	0.819	0.802	0.786	0.772	0.758	0.745	0.732	0.721	0.709	0.699
3.50	0.839	0.820	0.803	0.787	0.773	0.759	0.745	0.733	0.721	0.710	0.699
3.75	0.840	0.822	0.804	0.788	0.773	0.759	0.746	0.733	0.721	0.710	0.699
4.00	0.842	0.823	0.805	0.789	0.774	0.760	0.747	0.734	0.722	0.711	0.700
4.25	0.843	0.824	0.806	0.790	0.775	0.761	0.747	0.734	0.722	0.711	0.700
4.50	0.845	0.825	0.808	0.791	0.776	0.761	0.748	0.735	0.723	0.711	0.700
4.75	0.846	0.827	0.809	0.792	0.776	0.762	0.748	0.735	0.723	0.712	0.701
5.00	0.848	0.828	0.810	0.793	0.777	0.763	0.749	0.736	0.724	0.712	0.701
5.25	0.849	0.829	0.811	0.794	0.778	0.763	0.750	0.736	0.724	0.713	0.701
5.50	0.851	0.831	0.812	0.795	0.779	0.764	0.750	0.737	0.725	0.713	0.702
5.75	0.853	0.832	0.813	0.796	0.780	0.765	0.751	0.738	0.725	0.713	0.702
6.00	0.854	0.833	0.814	0.797	0.781	0.765	0.751	0.738	0.726	0.714	0.703
6.25	0.856	0.835	0.815	0.798	0.781	0.766	0.752	0.739	0.726	0.714	0.703
6.50	0.858	0.836	0.817	0.799	0.782	0.767	0.753	0.739	0.727	0.715	0.703
6.75	0.860	0.838	0.818	0.800	0.783	0.768	0.753	0.740	0.727	0.715	0.704
7.00	0.861	0.839	0.819	0.801	0.784	0.768	0.754	0.740	0.727	0.715	0.704
7.25	0.863	0.841	0.820	0.802	0.785	0.769	0.754	0.741	0.728	0.716	0.704
7.50	0.865	0.842	0.821	0.803	0.786	0.770	0.755	0.741	0.728	0.716	0.705
7.75	0.867	0.844	0.823	0.804	0.786	0.771	0.756	0.742	0.729	0.717	0.705
8.00	0.869	0.845	0.824	0.805	0.787	0.771	0.756	0.742	0.729	0.717	0.705
8.25	0.871	0.847	0.825	0.806	0.788	0.772	0.757	0.743	0.730	0.717	0.706
8.50	0.873	0.848	0.826	0.807	0.789	0.773	0.758	0.743	0.730	0.718	0.706
8.75	0.875	0.850	0.828	0.808	0.790	0.774	0.758	0.744	0.731	0.718	0.707
9.00	0.877	0.851	0.829	0.809	0.791	0.774	0.759	0.745	0.731	0.719	0.707
9.25	0.879	0.853	0.830	0.810	0.792	0.775	0.760	0.745	0.732	0.719	0.707
9.50	0.881	0.854	0.832	0.811	0.793	0.776	0.760	0.746	0.732	0.720	0.708
9.75	0.883	0.856	0.833	0.812	0.794	0.777	0.761	0.746	0.733	0.720	0.708
10.00	0.885	0.858	0.834	0.813	0.795	0.777	0.762	0.747	0.733	0.720	0.708
10.25	0.887	0.859	0.836	0.814	0.795	0.778	0.762	0.747	0.734	0.721	0.709
10.50	0.889	0.861	0.837	0.816	0.796	0.779	0.763	0.748	0.734	0.721	0.709
10.75	0.891	0.863	0.838	0.817	0.797	0.780	0.764	0.749	0.735	0.722	0.710
11.00	0.894	0.865	0.840	0.818	0.798	0.780	0.764	0.749	0.735	0.722	0.710
11.25	0.896	0.866	0.841	0.819	0.799	0.781	0.765	0.750	0.736	0.723	0.710
11.50	0.898	0.868	0.843	0.820	0.800	0.782	0.766	0.750	0.736	0.723	0.711
11.75	0.901	0.870	0.844	0.821	0.801	0.783	0.766	0.751	0.737	0.723	0.711
12.00	0.903	0.872	0.845	0.823	0.802	0.784	0.767	0.752	0.737	0.724	0.711
12.25	0.906	0.874	0.847	0.824	0.803	0.785	0.768	0.752	0.738	0.724	0.712
12.50	0.908	0.876	0.848	0.825	0.804	0.785	0.768	0.753	0.738	0.725	0.712
12.75	0.911	0.878	0.850	0.826	0.805	0.786	0.769	0.753	0.739	0.725	0.713
13.00	0.913	0.879	0.851	0.827	0.806	0.787	0.770	0.754	0.739	0.726	0.713

Table 2M
Supercritical Correction Factor, K_{sc} (Cont'd)

Flowing Pressure, MPa	Total Temperature, °C, of Supercritical Steam										
	400	425	450	475	500	525	550	575	600	625	650
13.25	0.916	0.881	0.853	0.829	0.807	0.788	0.770	0.755	0.740	0.726	0.713
13.50	0.919	0.883	0.855	0.830	0.808	0.789	0.771	0.755	0.740	0.727	0.714
13.75	0.921	0.886	0.856	0.831	0.809	0.790	0.772	0.756	0.741	0.727	0.714
14.00	0.924	0.888	0.858	0.832	0.810	0.790	0.773	0.756	0.741	0.727	0.715
14.25	0.927	0.890	0.859	0.834	0.811	0.791	0.773	0.757	0.742	0.728	0.715
14.50	0.930	0.892	0.861	0.835	0.812	0.792	0.774	0.758	0.742	0.728	0.715
14.75	0.933	0.894	0.863	0.836	0.813	0.793	0.775	0.758	0.743	0.729	0.716
15.00	0.936	0.896	0.864	0.838	0.814	0.794	0.776	0.759	0.743	0.729	0.716
15.25	0.939	0.898	0.866	0.839	0.815	0.795	0.776	0.759	0.744	0.730	0.717
15.50	0.942	0.901	0.868	0.840	0.817	0.796	0.777	0.760	0.745	0.730	0.717
15.75	0.946	0.903	0.869	0.842	0.818	0.797	0.778	0.761	0.745	0.731	0.717
16.00	0.949	0.905	0.871	0.843	0.819	0.797	0.778	0.761	0.746	0.731	0.718
16.25	0.952	0.908	0.873	0.844	0.820	0.798	0.779	0.762	0.746	0.732	0.718
16.50	0.956	0.910	0.875	0.846	0.821	0.799	0.780	0.763	0.747	0.732	0.719
16.75	0.959	0.912	0.876	0.847	0.822	0.800	0.781	0.763	0.747	0.733	0.719
17.00	0.963	0.915	0.878	0.848	0.823	0.801	0.782	0.764	0.748	0.733	0.719
17.25	0.966	0.917	0.880	0.850	0.824	0.802	0.782	0.765	0.748	0.734	0.720
17.50	0.970	0.920	0.882	0.851	0.825	0.803	0.783	0.765	0.749	0.734	0.720
17.75	0.974	0.923	0.884	0.853	0.827	0.804	0.784	0.766	0.749	0.734	0.721
18.00	0.978	0.925	0.886	0.854	0.828	0.805	0.785	0.767	0.750	0.735	0.721
18.25	0.982	0.928	0.888	0.856	0.829	0.806	0.785	0.767	0.751	0.735	0.721
18.50	0.986	0.931	0.890	0.857	0.830	0.807	0.786	0.768	0.751	0.736	0.722
18.75	0.991	0.933	0.892	0.859	0.831	0.808	0.787	0.769	0.752	0.736	0.722
19.00	0.995	0.936	0.894	0.860	0.833	0.809	0.788	0.769	0.752	0.737	0.723
19.25	1.000	0.939	0.896	0.862	0.834	0.810	0.789	0.770	0.753	0.737	0.723
19.50	1.005	0.942	0.898	0.863	0.835	0.811	0.789	0.771	0.753	0.738	0.724
19.75	1.009	0.945	0.900	0.865	0.836	0.812	0.790	0.771	0.754	0.738	0.724
20.00	1.014	0.948	0.902	0.867	0.837	0.813	0.791	0.772	0.755	0.739	0.724
20.25	1.020	0.951	0.904	0.868	0.839	0.814	0.792	0.773	0.755	0.739	0.725
20.50	1.025	0.954	0.906	0.870	0.840	0.815	0.793	0.773	0.756	0.740	0.725
20.75	1.030	0.958	0.909	0.871	0.841	0.816	0.794	0.774	0.756	0.740	0.726
21.00	1.035	0.961	0.911	0.873	0.843	0.817	0.794	0.775	0.757	0.741	0.726
21.25	1.040	0.964	0.913	0.875	0.844	0.818	0.795	0.775	0.758	0.741	0.727
21.50	1.044	0.968	0.916	0.876	0.845	0.819	0.796	0.776	0.758	0.742	0.727
21.75	1.049	0.971	0.918	0.878	0.846	0.820	0.797	0.777	0.759	0.742	0.727
22.00	1.054	0.975	0.920	0.880	0.848	0.821	0.798	0.777	0.759	0.743	0.728

Case 3068-1

Use of Alternative Category B Weld Design

Section VIII, Division 1

Approval Date: September 25, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: As an alternative to the dimensional requirements of UW-9(h), may Category B welds joining shells to formed heads be made with a weld preparation using a maximum 45 deg offset of the head, and the end of the offset protruding a minimum of $\frac{1}{8}$ in. (3 mm) into the inside of the shell course?

Reply: It is the opinion of the Committee that it is permissible to use Category B welds joining shells to formed heads with a weld preparation using a maximum 45 deg offset of the head, and the end of the offset protruding a minimum of $\frac{1}{8}$ in. (3 mm) into the inside of the shell course as shown in the [Figure 1](#), provided the following requirements are met:

(a) The vessel shall not be used for cyclic service, lethal service, direct firing, or as an unfired steam boiler.

(b) The maximum allowable working pressure (MAWP) of the vessel shall not exceed 360 psi (2 500 kPa).

(c) The design temperature shall not exceed 250°F (120°C).

(d) Neither the shell nor head shall have a nominal thickness of more than $\frac{1}{2}$ in. (13 mm).

(e) The outside shell diameter shall not exceed 32 in. (810 mm).

(f) The shell and the head shall be made of either P-No. 1 or P-No. 8 materials.

(g) The maximum difference in wall thickness between the shell and the head shall not exceed $\frac{3}{32}$ in. (2.5 mm).

(h) All heads shall be seamless and either of an ellipsoidal or a torispherical shape with L/r not exceeding 10.

(i) The head shall be provided with a minimum straight flange length of $1\frac{1}{2}t_h$.

(j) The shell shall be designed using a joint efficiency E of 0.85 or less.

(k) The Category B weld of the head to the shell shall have a joint efficiency E of 0.60 as required by Table UW-12, joint type 3.

(l) A workmanship assembly shall be welded, cross-sectioned, and etched. The section shall show that the weld was fully penetrated. The welding parameters specified in the welding procedure specification (WPS) shall be

the same as those used to make the root pass of the test assembly. More than one test assembly may be used to establish a range of parameters.

(m) The offset of the head shall be smooth and symmetrical with a minimum inside radius of $\frac{3}{32}$ in. (2.5 mm) but not less than $\frac{1}{4}t_h$ and shall not be machined or reduced in thickness.

(n) The offset of the head shall be examined in accordance with Mandatory Appendices 6 and 8 by magnetic particle or liquid penetrant for signs of laminations after forming and before welding. Grinding and repair are not allowed.

(o) The weld shall be placed from the outside only.

(p) The eccentricity between the head and the shell centerlines shall not exceed those shown in Figure UW-13.1, illustrations (i) through (l).

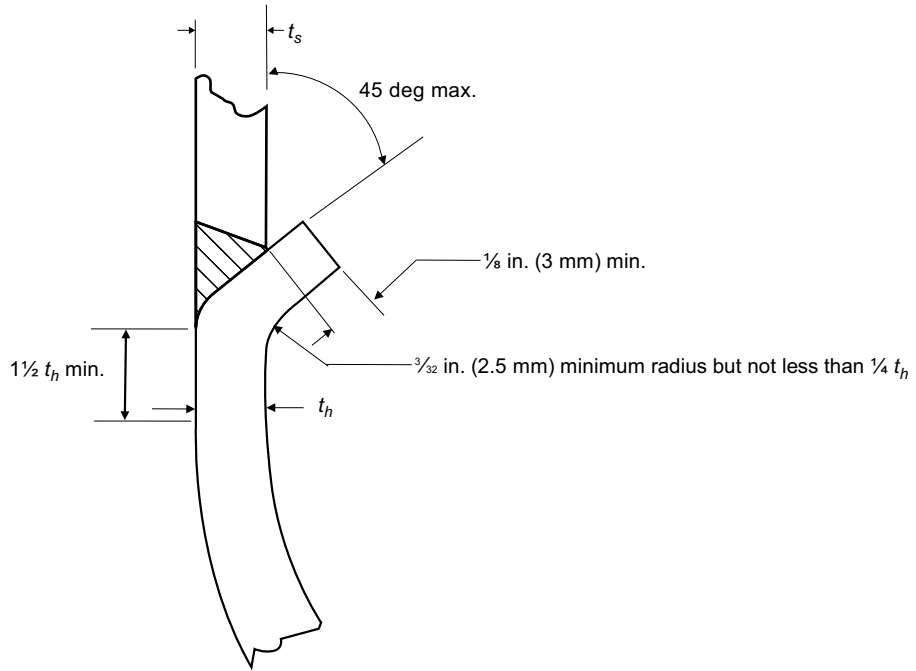
(q) The shell may be seamless or welded with a maximum out of roundness tolerance of 0.5%. For welded construction, the weld reinforcement on both the inside and outside of the shell shall be machined or ground flush with the base material for a minimum length of 1 in. (25 mm) from the end of the shell adjacent to the head.

(r) The root pass and outside surface of the completed head-to-shell weld shall be examined in accordance with Mandatory Appendix 6 or Mandatory Appendix 8 by magnetic particle or liquid penetrant.

(s) The vessel shall be hydrostatically tested per UG-99 or pneumatically tested per UG-100. If pneumatically tested, the requirements of UW-50 shall be followed.

(t) This Case number shall be referenced on the Manufacturer's Data Report.

Figure 1
Alternative Category B Weld Design



Legend:

- t_h = nominal thickness of head
- t_s = nominal thickness of shell

Case 3069

Use of Abbreviations in Lieu of Company Name or Identifying Trademark on Pressure Relief Devices

Section XIII

Approval Date: January 23, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May an ASME Certificate Holder use an acceptable abbreviation in lieu of the Manufacturer's name and/or Assembler's name if applicable as required in Section XIII, 3.9(e)(1)?

Reply: It is the opinion of the Committee that an acceptable abbreviation may be used on a pressure relief device in lieu of the Manufacturer's name and/or Assembler's name when applicable, provided all other marking requirements are followed.

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Case 3070

Use of Eddy Current for Surface Examination

(25)

Section VIII, Division 3

Approval Date: February 7, 2023

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may eddy current examination be used in lieu of the required magnetic particle or liquid penetrant examination in KE-233 for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that eddy current examination may be used in lieu of the required magnetic particle or liquid penetrant examination in

KE-233 for Section VIII, Division 3 construction, provided the following requirements are met:

(a) The eddy current examinations shall be in accordance with Section V, Article 8 and Mandatory Appendix IV, VI, VII, IX, or X, as applicable.

(b)) It shall be demonstrated that the eddy current examination to be performed is capable of finding relevant surface defects as defined in KE-233.2(a).

(c) The acceptance criteria for linear and rounded indications shall be as specified in KE-233.2(b). The definitions of linear and rounded indications contained in KE-233.1(c) apply.

(d) This Case number shall be recorded on the Manufacturer's Data Report.

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Case 3071

Laser Annealing of Vessel Marking

Section VIII, Division 2

Approval Date: April 23, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may laser annealing be used in marking, including the ASME Certification Mark in ASME CA-1, Figure 5.1.1-1 and Section VIII, Division 2, Annex 2-F, 2-F.5(b)(1), directly on a pressure vessel, by a Certificate Holder for pressure vessels constructed in accordance with Section VIII, Division 2 without marking depth limitation including that specified in Section VIII, Division 2, Annex 2-F, 2-F.7.1?

Reply: It is the opinion of the Committee that laser annealing may be used in marking, including the ASME Certification Mark in ASME CA-1, Figure 5.1.1-1 and Section VIII, Division 2, Annex 2-F, 2-F.5(b)(1), directly on a pressure vessel, by a Certificate Holder for pressure vessels constructed in accordance with Section VIII, Division 2 without marking depth limitation specified in Section VIII, Division 2, Annex 2-F, 2-F.7.1, provided the following requirements are met:

(a) Laser annealing shall be performed by the Manufacturer of the certified vessel.

(b) The required marking shall be applied on the vessel wall that is at least 0.5 mm (0.020 in.) thick.

(c) The material subjected to marking by laser annealing shall be limited to those specified in Case 3063.

(d) The data shall be in characters not less than 2 mm (0.08 in.) high and shall be readable for components 89 mm (3½ in.) or less in diameter.

(e) The arrangement and scope of marked data shall be in accordance with Section VIII, Division 2, Figure 2-F.1.

(f) The graphic image of the Certification Mark shall conform to the proportions of the official Certification Mark.

(g) The marking process shall leave a permanent and legible mark.

(h) The marking shall not be covered by insulation or other material unless the requirements of Section VIII, Division 2, Annex 2-F, 2-F.6 are met.

(i) No coating that obscures the laser annealing marking shall be allowed.

(j) The process controls for marking by laser annealing shall be described in the Quality Control System and shall be acceptable to the Authorized Inspector.

(k) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3072

Pressure Relief Valve Bodies and Bonnets or Yokes Using Additive Manufacturing

Section I

Approval Date: April 27, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: For Section I construction, may pressure relief valve bodies and bonnets or yokes be manufactured using Additive Manufacturing as an alternative to the processes associated with the material requirements in PG-73.3.3?

Reply: It is the opinion of the Committee that for Section I construction, pressure relief valve bodies and bonnets or yokes may be manufactured using Additive Manufacturing with powder bed fusion using both laser and electron beam energy sources, provided the following requirements are met:

(a) The maximum design temperature shall be at least 50°F (25°C) less than the temperature where time-dependent material properties begin to govern for the equivalent wrought ASME material specification, as indicated in Section II, Part D.

(b) The materials allowed for Additive Manufacturing shall be limited to austenitic stainless-steel alloys or nonferrous alloys.

(c) The Additive Manufacturer shall prepare an Additive Manufacturing Specification that provides all requirements and references to all construction documents for a component build including, but not limited to the following:

- (1) the governing Construction Code or Standard
- (2) the Design Report
- (3) file names with current revision for all model data describing the geometry of the component needed to build the physical component
- (4) the applicable Material Specification
- (5) the Powder Specification
- (6) the applicable ASME Construction Code or Standard Nondestructive Evaluation and Testing Requirements
- (7) post-processing requirements
- (8) thermal treatment requirements
- (9) all supplemental requirements identified by the Additive Manufacturer or the user

(10) Any supplemental examination requirements identified by the Additive Manufacturer or the user in addition to the requirements of the ASME Construction Code or Standard

The Additive Manufacturing Specification shall be included in the Additive Manufacturer's Construction Records.

(d) The Additive Manufacturer shall select a wrought ASME material specification from the ASME Boiler and Pressure Vessel Code Section II for the component material. The selected ASME material specification shall be identified in the Additive Manufacturing Specification. In this Case, the selected material specification is identified as the ASME material specification. The requirements for chemical composition, grain size (where applicable), hardness, final heat treatment, and mechanical properties shall meet the requirements of the ASME material specification. The properties of that material given in Section II, Part D shall be used for design purposes.

(e) The final heat treatment of the Additive Manufacturing material shall be as specified in the ASME material specification. All material testing shall be performed on material specimens in the final heat-treated condition of the ASME material specification.

(f) The Additive Manufacturer shall provide a Powder Specification for each powder batch to the Powder Supplier. As a minimum, the Powder Specification shall specify all pertinent powder characteristics, properties, and processing steps necessary to ensure the final product meets the ASME material specification requirements. All Powder Requirements shall be in accordance with ASME PTB-13-2021.

(g) In addition to the design requirements of Section I, the following design requirements apply for components produced using the powder bed fusion Additive Manufacturing process:

(1) Any material produced during the Additive Manufacturing build that is specified as cosmetic material shall not be credited as load-bearing material in the stress analysis.

(2) The effect of any support that will not be removed following the Additive Manufacturing build shall be included in the stress analysis.

(3) Supports that are credited as load-bearing in the stress analysis shall meet all relevant criteria identified in this Case.

(4) A design report is required for all additively manufactured components.

(h) The Additive Manufacturer shall prepare an Additive Manufacturing Procedure addressing the following requirements:

(1) The Additive Manufacturing Procedure shall address applicable processes listed in ASME PTB-13-2021, Table 7-1 and include any required tolerance limits for process variables. The Additive Manufacturer may include additional process variables.

(2) The requirements for Full, Partial, and Design Procedure Qualification based on a change in a process variable are prescribed in ASME PTB-13-2021, Table 7-1.

(3) Criteria for Full, Partial and Design procedure qualification are defined in ASME PTB-13-2021, Table 7-2.

(4) Full Qualification is required for any new Additive Manufacturing Procedure.

(5) Design requalification of the component is required when

(-a) a change in cosmetic material thickness results in a reduction of structural material in the component

(-b) a change in support material credited as load bearing results in a reduction of structural material or an increased stress concentration

(6) The Additive Manufacturing Procedure shall be included in the Additive Manufacturer's construction records.

(i) The Additive Manufacturer shall complete sufficient qualification builds and produce sufficient material qualification specimens to support with 95% confidence that 99% of the Additive Manufactured component material is in accordance with the selected ASME material specification. The statistical analysis shall be in accordance with ASTM E2586. The Additive Manufacturing Procedure Qualification shall be in accordance with the requirements in ASME PTB-13-2021, paras. 8(b) through 8(t).

(j) Fabricated components shall be subjected to qualification testing and shall be designated as Prototype Components. The Additive Manufacturer or its representative shall perform the qualification testing of the Prototype Components. Qualification Testing shall be in accordance with the requirements in ASME PTB-13-2021, paras. 9(c) through 9(n). Component

hydrostatic testing shall be performed by the pressure relief valve manufacturer in accordance with Section I, PG-73.5.1. Component fatigue testing is not required. The results of the required component qualification testing shall be documented in a Component Qualification Test Report.

(k) All production build cycles shall comply with the requirements of the Additive Manufacturing Specification and the qualified Additive Manufacturing Procedure. Witness specimens shall be constructed and tested with each production cycle, in accordance with the requirements in ASME PTB-13-2021, paras. 10(c) through 10(h). The tension test results for all tested witness samples shall be included in the Additive Manufacturer's construction records.

(l) Chemical composition testing shall be in accordance with the ASME material specification. The chemical composition of the specimens shall conform to the ASME material specification.

(m) Mechanical property testing shall be in accordance with the requirements in ASME PTB-13-2021, paras. 12(a) through 12(l).

(n) Metallographic evaluation shall be in accordance with the requirements in ASME PTB-13-2021, paras. 13(a) through 13(d).

(o) In-process monitoring methods that control machine operation are not permitted. In-process monitoring methods for data acquisition that do not control machine operation or do not automatically control any process qualification variable are permitted and are not required to be addressed in the Additive Manufacturing Procedure Qualification.

(p) The Additive Manufacturer and the Powder Supplier shall maintain a quality program consistent with the Section I. Oversight by an Authorized Inspector, Certified Individual, or ASME designee is not required.

(q) In addition to the requirements of Section I, the Additive Manufacturer shall maintain the following records:

(1) Additive Manufacturing Specification

(2) Powder Supplier Test Reports

(3) Additive Manufacturing Procedure

(4) Additive Manufacturing Procedure Qualification Test Report

(5) Additive Manufacturing Component Qualification Report

(6) Witness Sample Test Reports

(r) This Case number shall be marked on the pressure relief valve nameplate and Form P-8.

Case 3073

Alternative Specimen Validity Requirements

Section VIII, Division 3

Approval Date: April 23, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In lieu of the specimen validity requirements specified in KD-1043(a), KD-1043(d), KD-1045(d) and KD-1048(b), what alternative specimen validity requirements may be used in construction of Section VIII, Division 3 vessels?

Reply: It is the opinion of the Committee that in lieu of the specimen validity requirements specified in KD-1043(a), KD-1043(d), KD-1045(d) and KD-1048(b),

alternative specimen validity requirements may be used in construction of Section VIII, Division 3 vessels, provided the following requirements are met:

(a) Except as provided in (b), all specimens shall meet the validity requirements of ASTM E1681, para. 9.3.1.

(b) If the validity requirements of (a) are not met, then the validity requirements of ASTM E1681, para. 9.3.2 shall be met, provided the specimen thickness is greater than or equal to 85% of the design thickness of the vessel.

(c) This Case number shall be listed in the Manufacturer's Design Report and Manufacturer's Data Report.

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Case 3074

Use of UNS R50400 Titanium Seamless and Welded Tube in the Manufacture of Part HLW Water Heaters

Section IV

Approval Date: June 1, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS R50400 Grade 2 titanium in SB-338 seamless and welded tube be used in the welded construction of Section IV, Part HLW unlined water heaters?

Reply: It is the opinion of the Committee that UNS R50400 Grade 2 titanium in SB-338 seamless and welded tube may be used in the welded construction of Section IV, Part HLW unlined water heaters, provided the following requirements are met:

(a) The maximum allowable stress shall be as listed in [Table 1 \(Table 1M\)](#).

(b) Welding procedure and performance qualification shall be conducted in accordance with Section IX. This material shall be considered P-No. 51.

(c) The material's U values shall be those listed for SB-381, UNS R50400 Grade F-2 in Section II, Part D, Table U.

(d) The material's Y-1 values shall be those listed for SB-338, UNS R50400 Grade 2 in Section II, Part D, Table Y-1.

(e) For external pressure, Section II, Part D, Figure NPT-2 shall be used.

(f) The maximum design temperature shall be 500°F (260°C).

(g) All other applicable requirements of Section IV shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

NOTE: For product in welded form, the allowable stress values have been multiplied by a factor of 0.85.

Table 1
Maximum Allowable Stress Values for SB-338 Seamless and Welded Tube

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Seamless	Welded
100	12.5	10.6
200	10.9	9.3
300	9.1	7.7
400	7.7	6.6
500	6.7	5.7

Table 1M
Maximum Allowable Stress Values for SB-338 Seamless and Welded Tube

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Seamless	Welded
40	86.3	73.3
100	73.8	62.7
150	62.3	52.9
200	54.0	45.9
250	47.0	40.0
275 [Note (1)]	44.0	37.4

NOTE: (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.

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Case 3075

Design of Pressure Vessels for Refrigerated Liquefied Gases With Allowable Stress Based on the Smaller Value of Design Margin of 3.0 on Tensile Strength and 0.564 Times the 1% Proof Yield Strength

Section XII

Approval Date: December 8, 2022

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May pressure vessels built to Section XII, Modal Appendix 3, Article 1; Modal Appendix 1, Article 3; and Modal Appendix 1, Article 4, containing refrigerated liquefied gases and fabricated from the following listed austenitic stainless steels be designed using the allowable stress as the lower of $\frac{1}{3}$ of the minimum specified tensile strength or 0.564 times the 1% offset yield (1% proof) strength of the respective material, provided the following requirements are met?

- (a) EN 10028-7 Materials:
- (1) Grade X2CrNiMo17-12-2 (EN Material No. 1.4404)
 - (2) Grade X5CrNi18-10 (EN Material No. 1.4301)
 - (3) Grade X5CrNiMo17-12-2 (EN Material No. 1.4401)
 - (4) Grade X2CrNi18-10 (EN Material No. 1.4311)
 - (5) Grade X2CrNiMoN17-11-2 (EN Material No. 1.4406)
 - (6) Grade X5CrNiN19-9 (EN Material No. 1.4315)
 - (7) Grade X2CrNiMoN17-13-3 (EN Material No. 1.4429)
 - (8) Grade X6CrNiTi18-10 (EN Material No. 1.4541)
 - (9) Grade X2CrNi18-9 (EN Material No. 1.4307)
- (b) SA-240 Materials:
- (1) Type 304 (UNS S30400)
 - (2) Type 304N (UNS S30451)
 - (3) Type 304LN (UNS S30453)
 - (4) Type 304L (UNS S30403)
 - (5) Type 316 (UNS S31600)
 - (6) Type 316L (UNS S31603)
 - (7) Type 316LN (UNS S31653)
 - (8) Type 316N (UNS S31651)

Reply: It is the opinion of the Committee that the above referred grades of EN 10028-7 and SA-240 austenitic stainless steel plates may be used in the construction

of Section XII, Modal Appendix 1, Article 3; Modal Appendix 1, Article 4; and Modal Appendix 3, Article 1 tanks using the allowable stress as the lower of $\frac{1}{3}$ of the minimum specified tensile strength or 0.564 times the 1% offset yield (1% proof) strength of the respective material, provided the following requirements are met:

(a) All vessel butt weld seams are 100% radiographed using radiographic methods in accordance with Section VIII, Division 2, Part 7.

(b) Fatigue analysis as required in Section XII is performed for the pressure vessel, support attachments, and nozzles.

(c) Alignment tolerances for edges to be butt welded shall conform to the requirements of Section VIII, Division 2, 6.1.6.

(d) Specific requirements for welded joints shall conform to the requirements of Section VIII, Division 2, 6.2.4. Visible undercuts are not permitted.

(e) Miscellaneous welding requirements, where applicable, shall conform to the requirements of Section VIII, Division 2, 6.2.5.

(f) The head used shall be elliptical with an a/b ratio not exceeding 2 (where a is the inner radius of the head skirt, and b is the inner height of the head from the tangent line).

(g) The design temperature shall not exceed 100°F (38°C).

(h) Tensile and 0.2% and 1% offset yield strength shall be as shown in [Table 1 \(Table 1M\)](#).

(i) The maximum allowable stress values shall be those listed in [Table 2 \(Table 2M\)](#).

(j) For toughness requirements, Section XII, TM-250 rules apply. The EN material shall be considered equivalent to SA-240 materials that are shown in [Table 3](#).

(k) For external pressure chart, the EN material shall be considered equivalent to SA-240 materials that are shown in [Table 4](#).

(l) These materials shall be considered P-No. 8 and Group No. 1 materials.

(m) Welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(n) 1% offset yield strength values of the applicable EN and SA-240 materials allowed in this Case shall be provided in the material test report.

(o) Any weld repairs made to the material by the manufacturer shall be noted on the Data Report.

(p) If the following conditions prevail, the cold formed areas of pressure retaining components shall be solution annealed by heating at 1,900°F (1 040°C) for 20 min/in. (20 min/25 mm) of thickness or 10 min, whichever is greater, followed by rapid cooling after forming:

(1) for SA-240 grades: 304, 304L, 316, 316L material and EN 1.4301, 1.4307, 1.4401, 1.4404 if forming strain exceeds 20%

(2) for SA-240 grades: 304N, 304LN, 316N, 316LN, and EN 1.4311, 1.4315, 1.4429, 1.4406, 1.4541 if forming strain exceeds 15%

where forming strains are calculated per Section VIII, Division 2, Table 6.1.

(q) The allowable shear stress of the cylindrical shell shall be calculated using Section VIII, Division 2, 4.4.12.2(d).

(r) The inner vessel shall be designed for the design pressure using the maximum allowable stress values given in Table 2 (Table 2M) for the materials used.

(s) For the design loads specified in Section XII, Modal Appendix 1, 1-4.4 for Section XII, Modal Appendix 1, Article 4 tanks; the design loads specified in Section XII, Modal Appendix 1, 1-3.5.1(a)(1)(b) for Section XII, Modal Appendix 1, Article 3 tanks; and the design

loads specified in Section XII, Modal Appendix 3, 3-1.5 for Section XII, Modal Appendix 3, Article 1 tanks, the maximum allowable membrane stress values at any point in the vessel supports and in the vessel wall at support attachments shall not exceed the lesser of 33% of the specified minimum tensile strength and 56.4% of the specified minimum 1% offset yield strength of the materials used [see Table 1 (Table 1M)]. The local membrane plus bending stress shall not exceed 75% of the applicable yield strength. For the austenitic stainless steels listed, higher tensile strength and higher 1% offset yield strength values, and up to 115% of the minimum specified values in the applicable material standards may be used, provided these values are reported on the material test report.

(t) For pressure testing, the primary membrane stress in the vessel wall shall not exceed 90% of the 1% offset yield strength or 50% of the tensile strength, whichever is less at the test pressure. For the austenitic stainless steels listed, higher tensile strength and higher 1% offset yield strength values, and up to 115% of the minimum specified values in the applicable material standards may be used, provided these values are reported on the material test report.

(u) Prior to pressure testing, liquid penetrant testing shall be performed as required by Section XII, TE-240.1.

(v) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Tensile and Yield Strength Values

Steel Designation Numbers/ UNS Designation	Type/Grade	Tensile Strength at 100°F, ksi	0.2% Offset Yield Strength at 100°F, ksi	1% Offset Yield Strength at 100°F, ksi
S31603	316L	70	25	38
1.4404	X2CrNiMo17-12-2	75	32	38
S31600	316	75	30	38
1.4401	X5CrNiMo17-12-2	75	32	38
S31653	316LN	75	30	46
1.4406	X2CrNiMoN17-11-2	84	41	46
1.4429	X2CrNiMoN17-13-3	84	41	46
S30403	304L	70	25	35
1.4307	X2CrNi18-9	72	29	35
S30400	304	75	30	36
1.4301	X5CrNi18-10	75	31	36
S30453	304LN	75	30	45
1.4311	X2CrNiN18-10	80	39	45
S30451	304N	80	35	45
1.4315	X5CrNiN19-9	80	39	45
S32100	321	75	30	35
1.4541	X6CrNiTi18-10	72	29	35

Table 1M
Tensile and Yield Strength Values

Steel Designation Numbers/ UNS Designation	Type/Grade	Tensile Strength at 38°C, MPa	0.2% Offset Yield Strength at 38°C, MPa	1% Offset Yield Strength at 38°C, MPa
S31603	316L	485	170	260
1.4404	X2CrNiMo17-12-2	520	220	260
S31600	316	515	205	260
1.4401	X5CrNiMo17-12-2	520	220	260
S31653	316LN	515	205	320
1.4406	X2CrNiMoN17-11-2	580	280	320
1.4429	X2CrNiMoN17-13-3	580	280	320
S30403	304L	485	170	240
1.4307	X2CrNi18-9	500	200	240
S30400	304	515	205	250
1.4301	X5CrNi18-10	520	210	250
S30453	304LN	515	205	310
1.4311	X2CrNiN18-10	550	270	310
S30451	304N	550	240	310
1.4315	X5CrNiN19-9	550	270	310
S32100	321	515	205	240
1.4541	X6CrNiTi18-10	500	200	240

Table 2
Maximum Allowable Stress Values in Tension

Steel Designation Numbers/UNS Designation	Grade	Maximum Allowable Stress at 100°F, ksi
S31603	316L	21.4
1.4404	X2CrNiMo17-12-2	21.4
S31600	316	21.4
1.4401	X5CrNiMo17-12-2	21.4
S31653	316LN	25
1.4406	X2CrNiMoN17-11-2	25.9
1.4429	X2CrNiMoN17-13-3	25.9
S30403	304L	19.7
1.4307	X2CrNi18-9	19.7
S30400	304	20.3
1.4301	X5CrNi18-10	20.3
S30453	304LN	25
1.4311	X2CrNiN18-10	25.4
S30451	304N	25.4
1.4315	X5CrNiN19-9	25.4
S32100	321	19.7
1.4541	X6CrNiTi18-10	19.7

Table 2M
Maximum Allowable Stress Values in Tension

Steel Designation Numbers/UNS Designation	Grade	Maximum Allowable Stress at 38°C, MPa
S31603	316L	146.6
1.4404	X2CrNiMo17-12-2	146.6
S31600	316	146.6
1.4401	X5CrNiMo17-12-2	146.6
S31653	316LN	171.7
1.4406	X2CrNiMoN17-11-2	180.5
1.4429	X2CrNiMoN17-13-3	180.5
S30403	304L	135.4
1.4307	X2CrNi18-9	135.4
S30400	304	141
1.4301	X5CrNi18-10	141
S30453	304LN	171.7
1.4311	X2CrNiN18-10	174.8
S30451	304N	174.8
1.4315	X5CrNiN19-9	174.8
S32100	321	135.4
1.4541	X6CrNiTi18-10	135.4

Table 3
Equivalent EN 10028-7 to SA-240 for Toughness Rules

EN 10028-7 Material		SA-240 Material	
Steel Designation Number	Grade	UNS Designation	Grade
1.4404	X2CrNiMo17-12-2	S31603	316L
1.4401	X5CrNiMo17-12-2	S31600	316
1.4406, 1.4429	X2CrNiMoN17-11-2, X2CrNiMoN17-13-3	S31653	316LN
1.4307	X2CrNi18-9	S30403	304L
1.4301	X5CrNi18-10	S30400	304
1.4311	X2CrNi18-10	S30453	304LN
1.4315	X5CrNi19-9	S30451	304N
1.4541	X6CrNiTi18-10	S32100	321

Table 4
Equivalent EN 10028-7 to SA-240 for External Pressure

EN 10028-7 Material		SA-240 Material	
Steel Designation Number	Grade	UNS Designation	Grade
1.4404	X2CrNiMo17-12-2	S31603	316L
1.4401	X5CrNiMo17-12-2	S31600	316
1.4406, 1.4429	X2CrNiMoN17-11-2, X2CrNiMoN17-13-3	S31653	316LN
1.4307	X2CrNi18-9	S30403	304L
1.4301	X5CrNi18-10	S30400	304
1.4311	X2CrNi18-10	S30453	304LN
1.4315	X5CrNi19-9	S30451	304N
1.4541	X6CrNiTi18-10	S32100	321

Case 3076

Nozzle Neck Taper and Pipe Transition for NPS 2 and Less

Section VIII, Division 1

Approval Date: June 27, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In Section VIII, Division 1, Figure UW-13.4, illustration (a), under what conditions is a straight section at the end of the taper for the nozzle allowed when the nozzle is completely enclosed and protected from mechanical damage by a shell, casing, or ducting?

Reply: It is the opinion of the Committee that in Figure UW-13.4, illustration (a), a straight section at the end of the taper of the nozzle is allowed, provided the following requirements are met:

(a) The vessel, nozzle, and attached piping are enclosed and protected from mechanical damage by a shell, casing, or ducting [UG-16(b)(2)].

(b) The nozzle is NPS 2 (DN 50) or less.

(c) The nozzle neck thickness at the shell junction shall be no less than the thickness obtained in accordance with UG-45 rules.

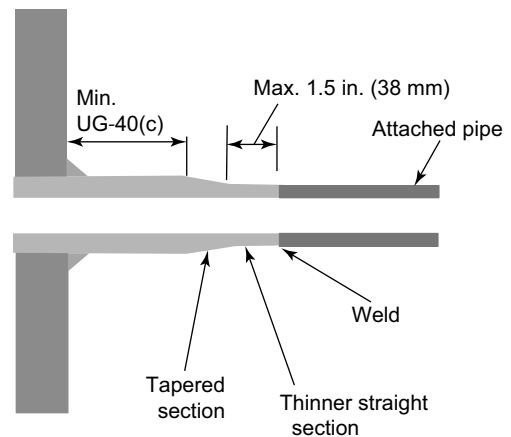
(d) The thicker section of the nozzle neck length shall be no less than the limits of reinforcement length calculated in accordance with UG-40(c) before the taper starts (see Figure 1).

(e) The neck thickness at the shell to nozzle junction may be transitioned to connecting pipe thickness, where the maximum transition taper angle does not exceed 30 deg.

(f) The minimum thickness, t_1 (thinner straight section of the nozzle neck as shown in Figure UW-13.4) shall not be less than the required thickness by the rules of UG-22, UG-27, UG-28, or Figure UW-13.4, and its length shall not be longer than 1.5 in. (38 mm).

(g) This Case number shall be shown on the Manufacturer's Data Report.

Figure 1
Nozzle Neck With a Transition Taper and Straight Section



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Case 3077 Nameplate Markings

Section IV

Approval Date: August 7, 2023


Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: The notes for Figures HG-530.2 and HG-530.3 (shown in [Figures 1](#) and [2](#), respectively) indicate that power input for electric boilers is to be shown in kilowatts. May the power input for electric boilers shown on the nameplate be in Btu/hr or Btu/hr and kilowatts rather than kilowatts only?

Reply: It is the opinion of the Committee that the rated power input for electric boilers may be shown in Btu/hr with or without the rating in kilowatts, provided the following requirements are met:

- (a) The units used for the input recorded on Form H-4 must match the units shown on the nameplate.
- (b) This Case number shall be shown on the Manufacturer's Data Report.

**Figure 1
Example of Electric Steam and Water Boilers Form of Marking on Completed Boilers or Their Nameplates (Not Applicable for Electric Boilers Constructed Primarily of Cast Iron)**


	Certified by _____ (Name of Manufacturer)
	¹ MAWP, Steam _____ ¹ MAWP, Water _____ ¹ Maximum Water Temp. _____
	² Power input _____ Minimum relief valve capacity _____ Manufacturer's serial no. _____ ³ Year built _____

GENERAL NOTE: Acceptable abbreviations of any of the wording may be used.

NOTES:

- (1) For steam only boilers, MAWP Water and Maximum Water Temperature markings are optional.
- (2) Input expressed in kW, Btu/hr, or Btu/hr and kW.
- (3) May be omitted when year built is prefix to serial number (see HG-530.1).

**Figure 2
Example of Electric Boilers Suitable for Water Only Form of Marking on Completed Boilers or Their Nameplates (Not Applicable for Electric Boilers Constructed Primarily of Cast Iron)**

	Certified by _____ (Name of Manufacturer)
	MAWP, Water _____ Maximum Water Temp. _____
	¹ Power input _____ Minimum relief valve capacity _____ Manufacturer's serial no. _____ ² Year built _____

GENERAL NOTE: Acceptable abbreviations of any of the wording may be used.

NOTES:

- (1) Input expressed in kW, Btu/hr, or Btu/hr and kW.
- (2) May be omitted when year built is prefix to serial number (see HG-530.1).

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Case 3078-1

Rules for Gasketed Electrochemical Cell Stacks for Electrolysis (25)

Section VIII, Division 1

Approval Date: December 10, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In the absence of rules covering gasketed electrochemical cell stacks in Section VIII, Division 1, what rules may be used to fabricate gasketed electrochemical cell stacks in compliance with Section VIII, Division 1?

Reply: It is the opinion of the Committee that the following rules may be used to fabricate gasketed electrochemical cell stacks in compliance with Section VIII, Division 1.

1 INTRODUCTION

Electrochemical cell stacks (ECS) are commonly used within electrochemical systems to carry out chemical reactions when supplied with electrical current and reactants (e.g., splitting water into hydrogen and oxygen gases as in electrolysis).

2 SCOPE

The rules in this Case cover the minimum requirements for materials, design, testing, and documentation of planar geometry gasketed electrochemical cell stacks (ECS) for electrolysis within the scope described in Section VIII, Division 1, U-1.

For ECS, the inside diameter dimension referred to in U-1(c)(2)(-i) shall be the largest distance measured between the inner edges of the sealing surfaces in the cross section of the ECS. For an ECS with rectangular or other non-circular cross section, the inside diameter shall be the longest diagonal.

These rules cover the gasketed ECS and their components but are not intended to limit the configurations or details to those illustrated or otherwise described herein. Designs that differ from those covered in this Case shall be in accordance with the provisions in U-2(g).

These rules apply to gasketed ECS that have a maximum design temperature below the boiling point of the electrolyte, but in no case exceeding 250°F (121°C).

ECS that are installed in an external vessel are exempted from the rules in this Case, provided that the external vessel meets the applicable rules of Division 1 unless exempted under U-1. The MAWP of the external vessel shall be no less than the design pressure of the ECS. The external vessel design shall consider abnormal pressures due to deflagration in UG-22(i) and Nonmandatory Appendix H for possible hydrogen and oxygen leaks from internal ECS.

This Case does not address the process and electrical safety requirements of ECS. These requirements are commonly found in other applicable safety standards such as CSA/ANSI B22734:23 or ISO 22734:2019.

3 MATERIALS

All pressure-retaining components shall be constructed using materials permitted by this Division except for dielectric materials, gasketed plate packs, membrane materials, and other internal ECS component materials used for the purpose of electrochemical process provided that the ECS meets the cell stack pressure and leak-test requirements of CSA/ANSI B22734:23 or ISO 22734:2019.

4 TERMINOLOGY

dielectric material: nonmetallic material with very low electrical conductivity (electrical insulator) that is essential for ECS construction. Planar electrical insulators interposed between internal cell stack, electrical terminal plate, and endplate are typically constructed of dielectric materials.

ECS compression bolt: a bolt assembly used to compress the endplates, gasketed cell plate packs, and other internal components to affect a pressure seal (see [Figure 1](#)).

electrical terminal plate: current conductor located at one or both terminal ends of the cell stack to conduct electrical current through the electrochemical cell stack. Electrical current connections are typically located on the endplate; (see [Figure 1](#)).

electrolyte: ion transport medium held within electrochemical cells.

endplate: structural support at either end of the cell stack used with bolts, springs, or other means to provide pressure containment and locations for the nozzles or connectors, and to minimize electrical resistance between cells.

gasket: a sealing element.

gasketed cell plate pack: a collection of all membrane electrochemical cells arranged as a pack. The gaskets provide periphery sealing between electrochemical cells and between anode and cathode cell compartments (see [Figure 1](#)).

gasketed electrochemical cell stack (ECS): an assembly of components including gasketed cell plate pack held in compression between endplates to establish gasketed fluid seals and minimize electrical resistance between cells. The compression loads may be accomplished by bolts, springs, hydraulics, or other means, (see [Figure 1](#)).

internal ECS components: electrochemical cell internal components, such as bipolar foils, meshes, seals, and porous structures that are used to collect or distribute electric current, collect or distribute fluids, or provide structural support to the cell membrane/separator; ECS electrical terminal plates and dielectric insulator plates are also considered as internal ECS components.

ion: electrically charged atom or group of atoms that transports through cell electrolyte during electrochemical reaction, for example: proton H^+ , hydroxyl OH^- , and others. Cations are positively charged ions, anions are negatively charged ions.

membrane/separator: material that provides selective fluid isolation between anode and cathode cell compartments, while allowing ionic transport via electrolyte within its structure.

membrane electrochemical cell: assembly of electrodes, fluid containment, fluid flow means, seals, or electrical current conduction means that include cell separation membranes.

5 APPLICABILITY

The design aspects covered in this Case apply to the metallic pressure-retaining components that are considered in the calculation of the MAWP as described in section 6. This Case does not address the design aspects of metallic or nonmetallic components that provide electrical insulation or electrical current distribution and facilitate ion conduction and separation.

6 MINIMUM DESIGN REQUIREMENTS

(a) Design of endplates, nozzle reinforcement, and ECS compression bolts shall follow the requirements of Division 1. Rectangular endplates shall be designed in accordance with Mandatory Appendix 45, 45-6.

(b) Gasketed cell plate pack shall be designed to contain pressurized fluid to a pressure of at least 1.5 times the MAWP. The MAWP of gasketed cell plate packs may be determined without performing proof testing or design calculations for the gasketed cell plate packs or other internal ECS components, provided the following requirements are met:

(1) The MAWP for gasketed ECS shall be determined considering metallic pressure-retaining endplates, bolting, and nozzles.

(2) Other pressure retaining components in gasketed cell plate packs and other internal ECS components are structurally supported by endplates.

7 PRESSURE TEST REQUIREMENTS

Hydrostatic or pneumatic tests shall be conducted on assembled ECS as a single chamber pressure vessel in accordance with the following requirements:

(a) The anode and cathode sides of ECS shall be tested simultaneously with a common pressure source.

(b) The common pressure test shall be performed in accordance with UG-99 or UG-100, except that the test pressure shall be at least 1.5 times MAWP for both hydrostatic and pneumatic tests. The use of lowest stress ratio (LSR) for test pressure calculations in UG-99(b) or UG-100(b) is not mandatory.

(c) The duration at test pressure shall be no less than 2 minutes.

(d) In lieu of the reduction factor of 1.3 in UG-99(g) and 1.1 in UG-100(e), the inspection for leakage after pressure test shall be made at a pressure not less than the test pressure divided by 1.5.

8 OVERPRESSURE PROTECTION

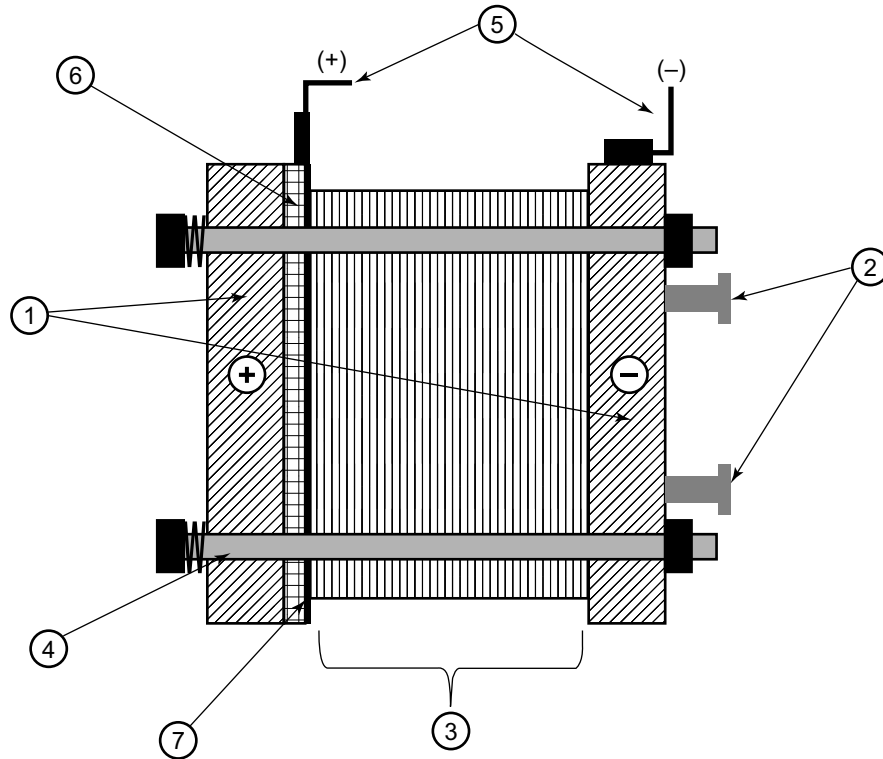
Overpressure protection shall comply with UG-150 through UG-156.

9 MARKING AND CERTIFICATION

This Case number shall be shown in the Manufacturer's Data Report. Additionally, the Manufacturer shall indicate in the Remarks section of the Manufacturer's Data Report that the ECS are compliant with CSA/ANSI B22734:23 or ISO 22734:2019.

Form U-1E as shown in [Nonmandatory Appendix A](#) shall be used for Manufacturer's Data Report. Alternatively, Form U-3E as shown in [Nonmandatory Appendix A](#) shall be used for ECS that meet the requirements of U-1(j). The ECS internal volume shall be the sum of both anode and cathode sides for pressure and volume consideration under U-1(j).

Figure 1
Example of an Electrochemical Cell Stack (ECS)



Legend:

- 1 = endplates
- 2 = nozzles
- 3 = cell plate pack that contains stacked and gasketed electrochemical cells
- 4 = ECS compression bolts with springs
- 5 = electrical current connections
- 6 = dielectric insulator plate
- 7 = electrical terminal plate

NONMANDATORY APPENDIX A

GUIDE FOR PREPARING MANUFACTURER'S DATA REPORT FORMS U-1E AND U-3E

(a) The instructions contained in this Appendix are to provide general guidance for the Manufacturer in preparing [Data Report Forms U-1E](#) and [U-3E](#) as required in this Case (see [Table A-1](#)).

(b) Manufacturer's Data Reports required by ASME Code rules are not intended for pressure vessels that do not meet the provisions of the Code, including those of special design or construction that require and receive approval by jurisdictional authorities under the laws, rules, and regulations of the respective state or municipality in which the vessel is to be installed.

(c) The instructions for the Data Reports are identified by parenthesized numbers corresponding to circled numbers on the sample Forms in this Appendix (see [Table A-1](#)).

(d) Where more space than has been provided for on the Form is needed for any item, indicate in the space, "See remarks," or "See attached Form U-4" as appropriate.

(e) Any quantity to which units apply shall be entered on the Manufacturer's Data Report with the chosen units.

(f) Manufacturer's Data Report Forms may be preprinted or computer generated. Forms shall be identical in size, arrangement, and content, as shown in this Appendix, or Form U-4 may be used.

When using forms that result in multiple pages, each page shall be marked to be traceable to the first page of the form. For [Form U-1E](#), each page shall contain, at the top of the page, as a minimum, the Manufacturer's name, Manufacturer's serial number, CRN (as applicable), and National Board number (as applicable), as shown on the first page of the form.

Additionally, each sheet shall contain the page number of that page and the total number of pages that compose the complete form.

FORM U-1E MANUFACTURER'S DATA REPORT FOR ELECTROCHEMICAL CELL STACKS
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by (1)
(Name and address of Manufacturer)

2. Manufactured for (2)
(Name and address of Purchaser)

3. Location of installation (3)
(Name and address)

4. Type (7) (8) (9) (10)
(Gasketed, other) (Manufacturer's serial no.) (CRN) (Drawing no.)

5. ASME Code, Section VIII, Div. 1 (13) (14) (15) (12)
[Edition (year)] (Code Case no.) [Special service per UG-120(d)] (Year built) (National Board no.)

6. Endplates: (20)
(Material)

Table with 5 columns: No., Quantity, Geometry, Thickness, Corr. Allow. Includes circled reference numbers 72, 21, 22.

7. Frame compression bolts and nuts (32)
(Quantity, diameter, material specification, and grade)

8. Impact test (38)
[Indicate yes or no and the component(s) impact tested]

9. Membrane electrochemical cells (73)
(Quantity of cells pressure tested)

10. MAWP (42) at max. temp (46), (37) MDMT at (29) Common hydro/pneu. pressure (49)

11. Nozzles, connections, inspections, and safety valve openings:

Table with 12 columns: Purpose, Qty., Dia. or Size, Type, Material (Nozzle, Flange), Flange Rating, Nozzle Thickness (Nom., C.A.), How Attached (Nozzle, Flange), Location (Insp./Open.). Includes circled reference numbers 41, 42, 43, 44, 45, 46, 48, 49, 50.

12. Supports: Lugs (51) Legs Feet (51) Others (51) Attached (51)
(Quantity) (Quantity) (Describe) (Where and how)

13. Manufacturer's Partial Data Reports properly identifying and signed by Commissioned Inspectors have been furnished for the following items of the report (list the name of the part, item number, and Manufacturer's name and identifying number): (52)

14. Remarks: (53)

FORM U-1E

Page ____ of ____

Manufactured by _____ ^⑨

Manufacturer's Serial No. _____ ^⑧ CRN _____ ^⑩ National Board No. _____ ^⑫

<p>^⑪</p> <p>CERTIFICATE OF SHOP COMPLIANCE</p> <p>We certify that the statements in this report are correct and that all details of design, material, construction, and workmanship of this electrochemical cell stack conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1.</p> <p>U Certificate of Authorization number _____ Expires _____</p> <p>Date _____ Name _____ (Manufacturer) Signed _____ (Representative)</p>
<p>^⑬</p> <p>CERTIFICATE OF SHOP INSPECTION</p> <p>I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by _____ of _____</p> <p>have inspected the electrochemical cell stack described in this Manufacturer's Data Report on _____, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this electrochemical cell stack in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the Inspector nor his/her employer makes any warranty, expressed or implied, concerning the electrochemical cell stack described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his/her 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.</p> <p>Date _____ Signed _____ (Authorized Inspector) Commissions _____ ^⑭ (National Board Authorized Inspector Commission number)</p>

(10/23)

FORM U-3E MANUFACTURER'S CERTIFICATE OF COMPLIANCE Page ____ of ____
FOR ELECTROCHEMICAL CELL STACKS
COVERING PRESSURE VESSELS TO BE STAMPED WITH THE UM DESIGNATOR [SEE U-1(j)]
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by _____ ^①

(Name and address of Manufacturer)

2. Manufactured for _____ ^②
(Name and address of Purchaser)

3. Location of installation _____ ^③
(Name and address)

4. Type _____ ^⑦ _____ ^⑧ _____ ^⑨ _____ ^⑩
(Gasketed, other) (Manufacturer's serial no.) (CRN) (Drawing no.)

5. ASME Code, Section VIII, Div. 1 _____ ^⑬ _____ ^⑭ _____ ^⑥ _____ ^⑫
[Edition (year)] (Code Case no.) (Capacity) (Year built) (National Board no.)

6. Endplates: _____ ^⑳
(Material)

No.	Quantity	Geometry	Thickness	Corr. Allow.
		^⑲	^㉑	^㉒

7. Frame compression bolts and nuts _____ ^㉓
(Quantity, diameter, material specification, and grade)

8. Impact test _____ ^㉔
[Indicate yes or no and the component(s) impact tested]

9. Membrane electrochemical cells _____ ^㉕
(Quantity of cells pressure tested)

10. MAWP ^㉖ at max. temp ^㉗, ^㉘ MDMT at ^㉙ Common hydro/pneu. pressure ^㉚

11. Nozzles, connections, inspections, and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	Qty.	Dia. or Size	Type	Material		Flange Rating	Nozzle Thickness		How Attached		Location (Insp./Open.)
				Nozzle	Flange		Nom.	C.A.	Nozzle	Flange	
^㉛		^㉜	^㉝	^㉞ ^㉟	^㊱ ^㊲	[㉫]	[㉬]	[㉭] [㉮]	[㉯] [㉰]	[㉱]	

12. Supports: Lugs _____ [㉲] Legs Feet _____ [㉳] Others _____ [㉴] Attached _____ [㉵]
(Quantity) (Quantity) (Describe) (Where and how)

13. Manufacturer's Partial Data Reports properly identifying and signed by Commissioned Inspectors have been furnished for the following items of the report (list the name of the part, item number, and Manufacturer's name and identifying number):
_____ [㉶]

14. Remarks: _____ [㉷]

(7/25)

FORM U-3E

Page ____ of ____

Manufactured by _____ ⁵⁹

Manufacturer's Serial No. _____ ⁸ CRN _____ ⁹ National Board No. _____ ¹²

<p>⁵⁹</p> <p>CERTIFICATE OF SHOP COMPLIANCE</p> <p>We certify that the statements in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1.</p> <p>UM Certificate of Authorization Number _____ ⁵⁹ Expires _____</p> <p>Date _____ Name _____ (Manufacturer) Signed _____ (Representative)</p> <p>Signed _____ ⁶⁵ (Certified Individual)</p>

(10/23)

Table A-1
Guide for Completing Forms

References to Circled Numbers in the Forms	Description										
(1)	Name, street address, city, state or province (as applicable), and country of Manufacturer as listed on ASME Certificate of Authorization.										
(2)	Name and address of purchaser.										
(3)	Name of user, and address where vessel is to be installed. If not known, so indicate (e.g., not known or built for stock).										
(6)	Indicate vessel capacity. See U-1(j).										
(8)	Manufacturer's serial number. See UG-116(a)(5).										
(9)	Canadian registration number, where applicable.										
(10)	Indicate drawing number(s), including applicable revision number, that cover general assembly and list of materials. For Canadian registered vessels, the number of the drawing approved by the provincial authorities										
(12)	Where applicable, the National Board number from the Manufacturer's Series of National Board numbers sequentially without skips or gaps.										
(13)	ASME Code, Section VIII, Division 1, Edition (e.g., 1989) and Addenda (e.g., A89, A90, etc.), if applicable, used for construction.										
(14)	All Code Case numbers and revisions used for construction must be listed. Where more space is needed use Remarks section or list on a supplemental page.										
(15)	Note any special service by Code paragraph as specified in UG-120(d) (e.g., lethal, low temperature, unfired steam boiler, direct fired).										
(20)	Show the complete ASME specification number and grade of the actual material used in the vessel. Material is to be as designated in Section VIII, Division 1 (e.g., SA-285C). Exceptions: A specification number for a material not identical to an ASME specification may be shown only if such material meets the criteria in the Code in conjunction with the Foreword of this Section. When material is accepted through a Code Case, the applicable Case number shall be shown.										
(21)	Thickness is the nominal thickness of the material used in the fabrication of the vessel shell. It includes corrosion allowance.										
(22)	State corrosion allowance (see UG-25).										
(32)	Bolts used to secure removable head or heads of vessel. Indicate the number, size, material specification (grade/type).										
(35)	Show maximum allowable working pressure (internal or external) for which vessel is constructed. See UG-118.										
(36)	Show maximum temperature permitted for vessel at MAWP. See (35).										
(37)	Indicate the minimum design metal temperature (MDMT).										
(38)	Indicate if impact testing was conducted (yes or no) and the component(s) that were impact tested and the impact test temperature. Where more space is needed, use Remarks section or list on a supplement page. If no, indicate applicable paragraph(s) [such as UG-20(f), UCS-66(a), UCS-66(b), or UCS-66(c), and UHA-51 or UHT-6].										
(39)	Indicate the type of test used (pneumatic, hydrostatic, or combination test, as applicable) and specify test pressure at the top of the vessel in the test position. Indicate under Remarks if the vessel was tested in the vertical position.										
(41)	Nozzles, inspection, and safety valve openings; list all openings, regardless of size and use. Where more space is needed, list them on a supplemental page.										
(42)	Indicate nozzles by size (NPS) and inspection openings by inside dimensions.										
(43)	Data entries with description acceptable to the Inspector. For all types of nozzles an abbreviation may be used to define any generic name. Some typical abbreviations: <table style="margin-left: 40px; border: none;"> <tr> <td>Flanged fabricated nozzle</td> <td>Cl. 150 flg.</td> </tr> <tr> <td>Long weld neck flange</td> <td>Cl. 300 lwn.</td> </tr> <tr> <td>Weld end fabricated nozzle</td> <td>w.e.</td> </tr> <tr> <td>Lap joint flange</td> <td>Cl. 150 lap jnt.</td> </tr> <tr> <td>Socket weld nozzle</td> <td>Cl. 3000 sw.</td> </tr> </table>	Flanged fabricated nozzle	Cl. 150 flg.	Long weld neck flange	Cl. 300 lwn.	Weld end fabricated nozzle	w.e.	Lap joint flange	Cl. 150 lap jnt.	Socket weld nozzle	Cl. 3000 sw.
Flanged fabricated nozzle	Cl. 150 flg.										
Long weld neck flange	Cl. 300 lwn.										
Weld end fabricated nozzle	w.e.										
Lap joint flange	Cl. 150 lap jnt.										
Socket weld nozzle	Cl. 3000 sw.										
(44)	Show the material for the nozzle neck.										
(45)	Show the material for the flange.										
(46)	Nominal thickness applies to nozzle neck thickness.										
(48)	Data entries with description acceptable to the Inspector. A code identification of Figure UW-16.1 (sketch no.) may be used to define the type of attachment.										
(49)	Category C and D welds — Identify degree of examination (radiographic or if applicable ultrasonic) employed: full, spot, or none (see UW-11). Also identify the joint efficiency associated with the weld from Table UW-12. When more space is needed, use Remarks section supplemental page or RT map, as applicable.										

Table A-1
Guide for Completing Forms (Cont'd)

References to Circled Numbers in the Forms	Description
(50)	Location applies to inspection openings only.
(51)	Describe: <i>(a)</i> type of support (skirt, lugs, etc.); <i>(b)</i> location of support (top, bottom, side, etc.); <i>(c)</i> method of attachment (bolted, welded, etc.).
(52)	To be completed when one or more parts of the vessel are furnished by others and certified on Data Report U-2 or U-2A. The part Manufacturer's name and serial number required by UG-116 should be indicated.
(53)	Space for additional comments including any Code restrictions on the vessel, or any unusual requirements that have been met, such as those in U-2(g), UG-11, UG-19(a)(2), UG-19(a)(3), UG-46, UG-53, UG-79, UG-90(c)(2), UG-99(e)(2), UG-115, UG-119(g), UG-120(b), UG-120(d), and UG-120(f), or in other notes to this Table. Indicate stiffening rings when used. See W-1(d) or W-1(e) when additional space is needed. List any pressure-retaining covers and their attaching bolting and nuts. The minimum information shall include the material specification, material grade, size, and thread designation.
(58)	The name of the Manufacturer as shown on his ASME Code Certificate of Authorization.
(59)	Manufacturer's authorization number to use the Certification Mark with the UM Designator from his Certificate of Authorization.
(60)	Certificate of Shop Inspection block is to be completed by the Manufacturer and signed by the Authorized Inspector who performs the inspection.
(61)	The National Board Authorized Inspector Commission number must be shown.
(65)	Signature of Certified Individual indicates Certification Mark with the appropriate Designator has been applied in accordance with the requirements of Section VIII, Division 1.
(71)	Indicate whether the cell plates are gasketed, or other construction.
(72)	Indicate end plate geometry and dimensions: <i>(a)</i> Circular: diameter <i>(b)</i> Rectangle: length and width <i>(c)</i> Other: provide detail descriptions and dimensions, if more space is needed, use "Remarks" section or list on a supplement page.
(73)	Describe: quantity of membrane electrochemical cells installed at time of pressure test.

Case 3079

Alternative Weld Flaw Acceptance Criteria

(25)

Section VIII, Division 3

Approval Date: September 18, 2023

Impending Annulment Date: January 1, 2026

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the Manufacturer develop acceptance criteria for ultrasonic examination of welds in lieu of using the acceptance criteria in Section VIII, Division 3, Article KE-3, KE-301(i)(3)(-d)?

Reply: The Manufacturer may develop acceptance criteria for ultrasonic examinations of welds in lieu of using the acceptance criteria in Section VIII, Division 3, Article KE-3, KE-301(i)(3)(-d), provided the following requirements are met:

(a) The Manufacturer shall develop a table of alternative flaw acceptance criteria for every weld that is to use alternate criteria from Article KE-3.

(1) The flaw acceptance criteria shall be developed based on the initial flaw sizes used in the fracture mechanics life assessment in Article KD-4.

(2) The flaw acceptance criteria shall be equal to or less than the initial flaw size used in each flaw evaluation in Article KD-4.

(3) The use of this Case shall be documented in the User's Design Specification signifying acceptance of the User.

(b) A table of acceptable flaw sizes shall be developed for each weld.

(1) The table shall include the following:

(-a) a surface-connected flaw that is parallel to the weld axis

(-b) a surface-connected flaw that is perpendicular to the weld axis

(-c) a subsurface flaw that is parallel to the weld axis

(-d) a subsurface flaw that is perpendicular to the weld axis

The definition of a surface connected flaw from Figure KE-301-1 shall be used.

(2) The table shall include the following aspect ratios as a minimum:

(-a) 2 units long to 1 unit deep

(-b) 3 units long to 1 unit deep

(-c) 6 units long to 1 unit deep

(3) The specific geometry of each weld shall be used in the fracture mechanics evaluations.

(4) All loading conditions, including any residual stresses considering the amount of postweld heat treatment (PWHT) used shall be considered for each weld.

(c) Personnel performing the examination and who acquire and analyze the UT data shall use the table of acceptance criteria generated in (b).

(1) Interpolation between aspect ratios in the table is permitted.

(2) All flaws with aspect ratios larger or smaller than those in the table generated are to be considered relevant by the examiner and documented.

(3) Any flaws with aspect ratios larger or smaller than those in the table generated by this Case shall be evaluated using a specific fracture mechanics calculation in accordance with KD-4 to determine if they are acceptable.

(d) This Case number shall be listed in the Manufacturer's Design Report and on the Manufacturer's Data Report.

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Case 3080

Use of SA-372/SA-372M, Grade J, Class 70 (1 Cr-¹/₅ Mo) Material as Seamless Pipe

Section VIII, Division 3

Approval Date: October 9, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may SA-372/SA-372M, Grade J, Class 70 (1Cr-¹/₅Mo) material be used in the form of seamless pipe in the construction of Section VIII, Division 3 wire-wound pressure vessels?

Reply: It is the opinion of the Committee that SA-372/SA-372M, Grade J, Class 70 (1Cr-¹/₅Mo) material may be used in the form of seamless pipe for the construction of Section VIII, Division 3 wire-wound pressure vessels, provided the following requirements are met:

(a) The seamless pipe shall meet all requirements of SA-372/SA-372M for Grade J, Class 70, except for SA-372/SA-372M, para 4.2.1.

(1) Marking shall include the suffix "Y" following the ASTM number, as required by SA-788/SA-788M, para. 17.1.7 to indicate an incomplete forging.

(2) The certification shall include all requirements listed in SA-788/SA-788M including extent to which the forging is incomplete as required in para. 16.1.8.

(b) All applicable requirements for SA-372/SA-372M, Grade J, Class 70 in Section VIII, Division 3 shall be met, such as, but not limited to, Articles KD-9, KF-9, and KM-2.

(c) Welding is not permitted, including weld repair.

(d) The tensile strength values, S_u , shall be those shown in Section II, Part D, Table U for SA-372/SA-372M, Grade J, Class 70 material.

(e) The yield strength values, S_y , shall be those shown in Section II, Part D, Table Y-1 for SA-372/SA-372M, Grade J, Class 70 material.

(f) Physical properties may be taken from Section II, Part D for Carbon and Low Alloy Steels, Material Group C (1Cr-¹/₅Mo) or from data obtained by the user when permitted in Section II, Part D, Subpart 2.

(g) The design temperature shall not exceed 650°F (343°C).

(h) This Case number shall be shown on the marking, certification of the material, and on the Manufacturer's Data Report.

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Case 3081

Single Side Weld for Fittings, Nozzles for Construction of Water Heating Boiler

Section IV

Approval Date: December 18, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Is it permissible to perform fillet weld deposited from the outside only for fittings, nozzles, or equivalent bolting pads not exceeding NPS 4 (DN 100) in the construction of hot water heating boilers and hot water supply boilers?

Reply: It is the opinion of the Committee that it is permissible to perform fillet weld deposited from the outside only for fittings, nozzles, or equivalent bolting pads not exceeding NPS 4 (DN 100) in the construction of hot water heating boilers and hot water supply boilers, provided the following requirements are met:

(a) Fittings, nozzles, or equivalent bolting pads shall not exceed NPS 4 (DN 100).

(b) The fillet weld deposited from the outside shall have the minimum dimensions shown in Section IV, Figure HW-731, sketches (o) through (t).

(c) The boiler wall thickness shall not exceed $\frac{3}{8}$ in. (10 mm).

(d) Design of the connection, including required opening reinforcement, shall be calculated using applicable Section IV Code formulas. In cases where design rules do not exist, the proof test in accordance with HG-502.3 shall be performed.

(e) All other requirements of Section IV shall be met.

(f) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3082

Alternate Safety Certification of Safety Controls for Boilers and Water Heaters

Section IV

Approval Date: December 18, 2023

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may safety controls that are labeled and listed as complying with UL 60730-1, Standard for Safety, Automatic Electrical Controls – Part 1: General Requirements, rather than UL 353, Standard for Limit Controls, be used to meet the requirements of Section IV, Parts HG-605, HG-606, HG-613, and HG-614?

Reply: It is the opinion of the Committee that safety controls that are labeled and listed as complying with UL 60730-1, Standard for Safety, Automatic Electrical Controls – Part 1: General Requirements rather than UL 353, Standard for Limit Controls, may be used to meet the requirements of ASME Section IV Parts HG-

605, HG-606, HG-613, and HG-614, provided the following requirements are met:

(a) The labeling and listing also includes the following:

(1) UL 60730-2-9, Standard for Safety, Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, for temperature controls in HG-613, or

(2) UL 60730-2-6, Standard for Safety, Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, for pressure controls in HG-605, or

(3) UL 60730-2-15, Standard for Safety, Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Air Flow, Water Flow and Water Level Sensing Controls, for low-water cutoffs in HG-606 and HG-614

(b) All other requirements of Section IV shall be met.

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Case 3083

Titanium Aluminum Vanadium Iron Alloy, Grade 38 (Ti 4Al-2.5V-1.5Fe), UNS R54250

Section VIII, Division 2

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May titanium Grade 38 (Ti 4Al-2.5V-1.5Fe) alloy be used in Section VIII, Division 2 construction?

Reply: It is the opinion of the Committee that the titanium Grade 38 (Ti 4Al-2.5V-1.5Fe) alloy may be used in Section VIII, Division 2 construction, provided the following requirements are met:

(a) The material shall meet the product specification requirements in [Table 1](#).

(b) The maximum allowable stress values for Class 1 vessels shall be as shown in [Table 2](#) or [Table 2M](#). The maximum design temperature shall not exceed 650°F (343°C).

(c) The maximum allowable stress values for Class 2 vessels shall be as shown in [Table 3](#) or [Table 3M](#). The maximum design temperature shall not exceed 650°F (343°C).

(d) Welding/brazing procedure and performance qualifications shall be conducted in accordance with Section IX (welding P-No. 54, brazing P-No. 500).

(e) The vessels shall not be in cyclic service.

(f) The physical properties in Section II, Part D, Subpart 2 for UNS R54250 shall be used.

(g) All other rules for Section VIII, Division 2 applicable to titanium shall be met.

(h) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Product Specifications

Product	Specification	Grade
Bar, billet	SB-348	38
Forgings	SB-381	F-38
Plate, sheet, strip	SB-265	38
Seamless and welded fittings	SB-363	WPT38, WPT38W
Seamless pipe	SB-861	38
Seamless tube	SB-338	38
Welded pipe	SB-862	38
Welded tube	SB-338	38

Table 2
Maximum Allowable Stress Values (All Product Forms)
for Class 1 Vessels

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Wrought	Welded Pipe, Tube, Fittings [Note (1)]
100	43.3	36.8
150	43.3	36.8
200	43.0	36.6
250	41.2	35.0
300	39.4	33.5
350	37.7	32.0
400	36.2	30.8
500	33.8	28.7
550	33.0	28.0
600	32.3	27.5
650	31.8	27.0

NOTE: (1) A factor of 0.85 has been used in establishing these allowable stresses.

Table 2M
Maximum Allowable Stress Values (All Product Forms)
for Class 1 Vessels

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Wrought	Welded Pipe, Tube, Fittings [Note (1)]
40	299	254
65	299	254
100	294	250
125	282	240
150	271	230
175	261	221
200	251	213
225	243	206
250	236	200
275	230	195
300	225	191
325	221	188
350 [Note (2)]	219	186

NOTES:

- (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.
- (2) Values for 350°C are provided for interpolation purposes only.

Table 3
Maximum Allowable Stress Values (All Product Forms)
for Class 2 Vessels

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	
	Wrought	Welded Pipe, Tube, Fittings [Note (1)]
100	54.2	46.0
150	54.2	46.0
200	54.2	46.0
250	54.2	46.0
300	54.2	46.0
350	54.2	46.0
400	54.2	46.0
500	49.7	42.3
550	47.9	40.7
600	46.3	39.4
650	44.8	38.1

NOTE: (1) A factor of 0.85 has been used in establishing these allowable stresses.

Table 3M
Maximum Allowable Stress Values (All Product Forms)
for Class 2 Vessels

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	
	Wrought	Welded Pipe, Tube, Fittings [Note (1)]
40	378	317
65	378	317
100	378	317
125	378	317
150	378	317
175	378	317
200	378	317
225	362	307
250	248	296
275	336	286
300	325	277
325	316	268
350 [Note (2)]	307	261

NOTES:

- (1) The maximum use temperature shall be 260°C. Datum for 275°C temperature is provided for interpolation purposes.
- (2) Values for 350°C are provided for interpolation purposes only.

Case 3084

Pressure Vessel With Firetube(s)

Section VIII, Division 1

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a pressure vessel with firetube(s) be constructed to Section VIII, Division 1?

Reply: It is the opinion of the Committee that a pressure vessel with firetube(s) may be constructed to Section VIII, Division 1, provided the following requirements are met.

1 SCOPE

The rules of this Case address additional requirements for the construction of a pressure vessel with firetube(s). The main pressure retaining components are the pressure vessel chamber that contains the process fluid and a typically U-shaped firetube assembly through which combustion gases pass to the atmosphere. The firetube is a direct fired component [see UW-2(d)] that provides a heat source to the process medium and is an internal pressure boundary of the vessel (see [Figure 1](#)).

These rules cover common configurations of a pressure vessel with a firetube(s) but are not intended to limit the configurations or details to those illustrated or otherwise described herein.

2 TERMINOLOGY

firetube assembly: the firetube heating element of the vessel consists of straight sections of cylindrical shells, curved or mitered segments, and typically a firetube cover plate (see [Figure 1](#)).

miter joint: the connection between two straight sections of cylindrical shell in a plane bisecting the angle of junction to produce a change in direction.

3 MATERIALS OF CONSTRUCTION

Materials shall be limited to those permitted by Section VIII, Division 1.

4 DESIGN

4.1 LOADINGS

(a) In addition to all the applicable loadings in UG-22, the design of the firetube and cover plate flange assembly shall also consider the following:

- (1) buoyancy forces
- (2) firetube friction force against supports due to thermal expansion
- (3) spacing between the tubes in the overall performance of the equipment
- (4) firetube and cover plate flange assembly insertion and extraction forces

(b) When sizing the firetube and cover plate flange assembly support arrangement, the most severe loading combinations shall be considered.

(c) Localized stresses due to nonpressure parts attached to pressure parts shall not exceed their respective allowable stresses. See Section VIII, Division 1, Non-mandatory Appendix G for further guidelines.

4.2 FIRETUBES

The firetubes are subject to external pressure from the process conditions and atmospheric or low internal pressure [i.e., less than 15 psi (100 kPa)] from products of combustion. Firetubes are subject to direct firing and the rules of UW-2(d) shall be applied.

With the exception of the definition of L given below, firetubes shall meet the design rules in UG-28, UG-29, UG-30, and UG-31 for external pressure in addition to UG-27 for internal pressure (if applicable).

The rules for curved and mitered segments of cylindrical shells subjected to external pressure shall be determined as specified for straight sections of cylindrical shell. The design length, L , is as depicted in [Figure 2](#) for a firetube containing miters and may be stiffened in accordance with UG-29.

4.3 CALCULATION PROCEDURE FOR OBOUND FLAT FACE FLANGE WITH FULL FACE GASKETS EXTENDING OUTSIDE THE BOLT CIRCLE DIAMETER

(a) *Notation.* The symbols described below are in addition to or modify those in Section VIII, Division 1, Mandatory Appendix 2, 2-3 (see also [Figure 3](#)).

- A_1 = inside diameter of the gasket or the inside diameter of the gasket contact face, whichever is less
- b_o' = basic gasket seating width effective under initial tightening = $\min.(G_o - C, C - A_1)$
- b' = effective gasket seating width = $4\sqrt{b_o'}$
- $2b''$ = effective gasket contact width under pressure, taken as 0.2 in. (5 mm)
- d_h = diameter of the bolt hole
- E = flange modulus of elasticity at design temperature
- E_a = flange modulus of elasticity at atmospheric temperature
- $G = C - (d_h + 2b'')$
- G_o = outside diameter of gasket or outside diameter of flange, whichever is less
- H = total hydrostatic end force = $[\pi/4(C - d_h)^2 + 2(C - d_h)L_2]P$
- H_D = hydrostatic end force on area inside of the flange = $(\pi/4B^2 + 2BL_2)P$
- H_G = compression load on gasket to ensure tight joint = $2b''(\pi G + 4L_2)mP$
- H_R = balancing reaction force outside the bolt circle in opposition to moments due to loads inside bolt circle = $(H_D h_D + H_T h_T + H_G h_G)/h_R$
- h_G = radial distance from bolt circle to circle on which H_G acts = $(d_h + 2b'')/2$
- h_R = radial distance from bolt circle to circle on which H_R acts = $(G_o - C + d_h)/4$
- h_T = radial distance from bolt circle to circle on which H_T acts = $(C + d_h + 2b'' - B)/4$
- L_2 = half-length of long side plate of obround flange
- M = balancing radial moment in flange along the line of bolt holes = $H_R h_R$
- n = number of bolt holes
- R_E = ratio of modulus of elasticity for design temperature to atmospheric temperature = E/E_a

(b) *Flange Types*: Obround flat faced flanges with full face gaskets shall be considered as loose type or optional type flanges as defined in Mandatory Appendix 2, 2-4.

(c) *Bolts*. The bolting loads of obround flange joint bolts shall be determined using the methodology described in Mandatory Appendix 2, 2-5 except 1, eqs. (1) and (2) below shall be used in lieu of equations (1) and (2) of Mandatory Appendix 2, 2-5.

(1) The required bolt load for the operating conditions W_{m1} is determined in accordance with eq. (1).

$$W_{m1} = H + H_G + H_R \quad (1)$$

(2) The minimum initial bolt load required for non-circular shaped gasket seating condition W_{m2} is determined in accordance with eq. (2).

$$W_{m2} = (\pi C + 4L_2)b'y/K_c \quad (2)$$

where $K_c = 1$ for SI Units and $K_c = 5$ for U.S. Customary units

(3) There is no minimum or maximum bolt spacing.

(d) *Obround Flange Thickness*. Obround flange minimum thickness shall be determined as the maximum value of t per eqs. (3) and (4).

$$t = \sqrt{\frac{6M}{S_f(\pi C + 4L_2 - nd_h)}} \quad (3)$$

$$t = (M + 0.5)(B_s - 2a)/(6R_E^{0.25}) \quad (4)$$

4.4 THICKNESS OF OBROUND NOZZLES

(a) The design of obround nozzles shall be determined using the rules in Mandatory Appendix 13, section 13-10, 13-11, or 13-12 for the configurations presented in Section VIII, Division 1, Figure 13-2(b).

(b) The rules in this Case are established to cover some common types of obround cross section nozzles but are not intended to limit configurations to those illustrated or otherwise described in Figure 13-2(b). For configurations other than those in Mandatory Appendix 13, see U-2(g).

(c) For determination of minimum nozzle wall thickness per UG-45, t_a shall be as determined in (a) above and t_{b3} shall be selected based on the long side dimension, $2L_2$, per Figure 3.

4.5 OPENINGS IN OBROUND NOZZLES

Openings may be provided in nozzles of obround cross section and shall be designed using the methodology described in Section VIII, Division 1, Mandatory Appendix 13, 13-4(j).

4.6 OBROUND NOZZLE REINFORCEMENT

The reinforcement of openings shall comply with UG-36 through UG-43.

4.7 FIRETUBE COVER PLATE

The design of the firetube cover plate shall be designed in accordance with U-2(g).

5 PRESSURE TEST REQUIREMENTS

The complete pressure vessel with firetube assembly shall be pressure tested in accordance with UG-99.

6 MARKING

6.1 PRESSURE VESSEL WITH FIRETUBE ASSEMBLY

(a) Each pressure vessel with a firetube assembly shall be marked in accordance with the requirements of UG-116 except as modified herein.

(b) The type of construction shall be indicated directly below the Certification Mark and U Designator by applying the letters "DF" [see UG-116(c) and UW-2(d)].

(c) In addition to the requirements of UG-116(a), the firetube design temperature shall be listed on the vessel nameplate.

(d) A firetube assembly supplied with the pressure vessel shall be marked in accordance with UG-116(k).

6.2 FIRETUBE ASSEMBLY SUPPLIED AS A PART

(a) A firetube assembly supplied as a part shall be marked in accordance with the requirements of UG-116(h) except as modified herein.

(b) The type of construction shall be indicated directly below the Certification Mark and U PART or PRT VIII-1 Designator by applying the letters "DF" [see UG-116(c) and UW-2(d)].

(c) In addition to the requirements of UG-116(h), the firetube design temperature shall be listed on the part (PART or PRT VIII-1) nameplate.

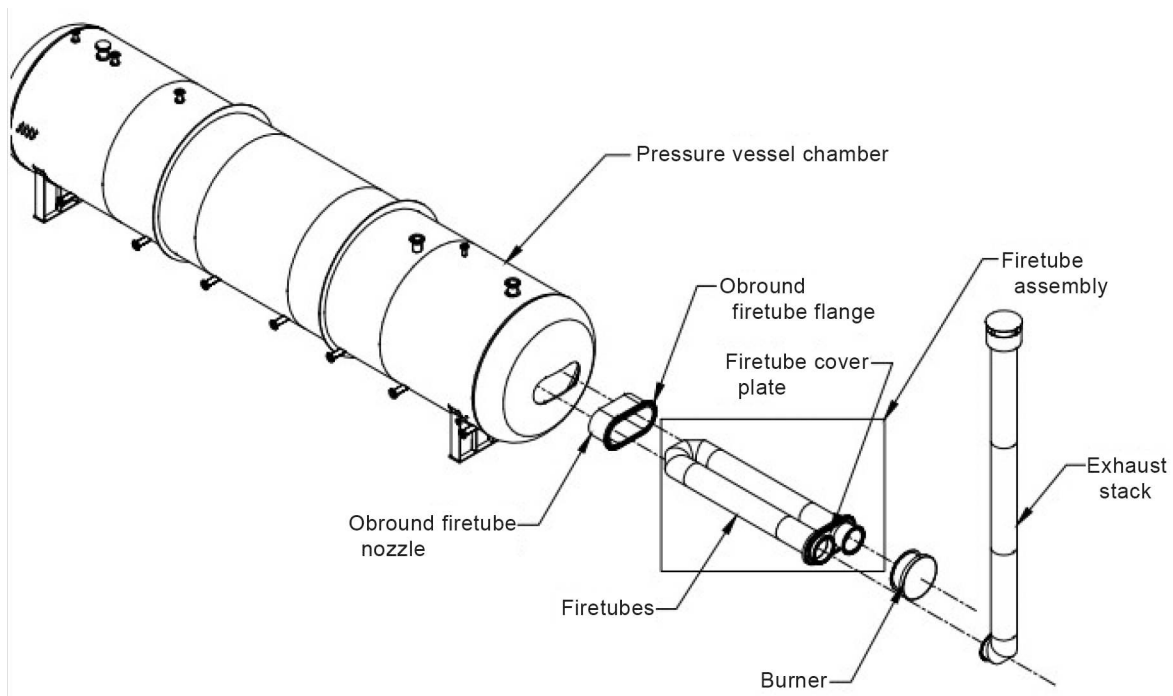
7 MANUFACTURER'S DATA REPORTS

(a) A removable firetube supplied along with the pressure vessel shall be included on the Manufacturer's Data Report in the remarks section or on Form U-4 per UG-120(e).

(b) A firetube supplied as standalone item, for example as replacement or spare part, shall be reported on a Partial Data Report in accordance with UG-120(c).

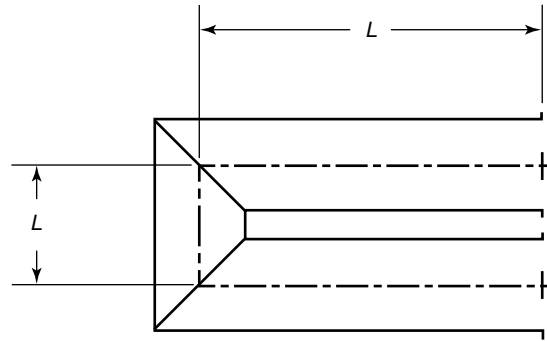
(c) This Case number shall be shown on the Manufacturer's Data Report and/or Manufacturer's Partial Data Report.

Figure 1
Typical Pressure Vessel With Firetube(s)

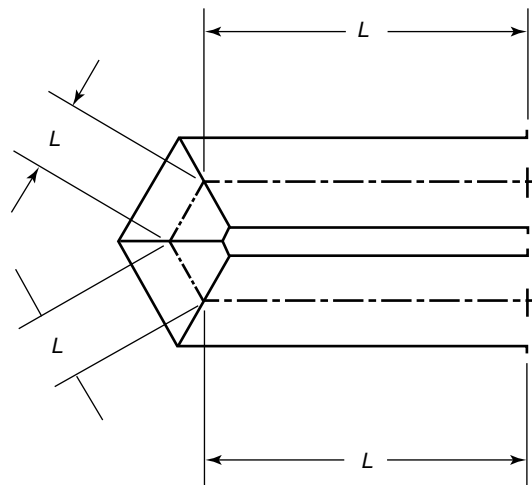


GENERAL NOTE: The burner and exhaust stack are not considered part of the Code scope.

Figure 2
Miter Joint Line of Support

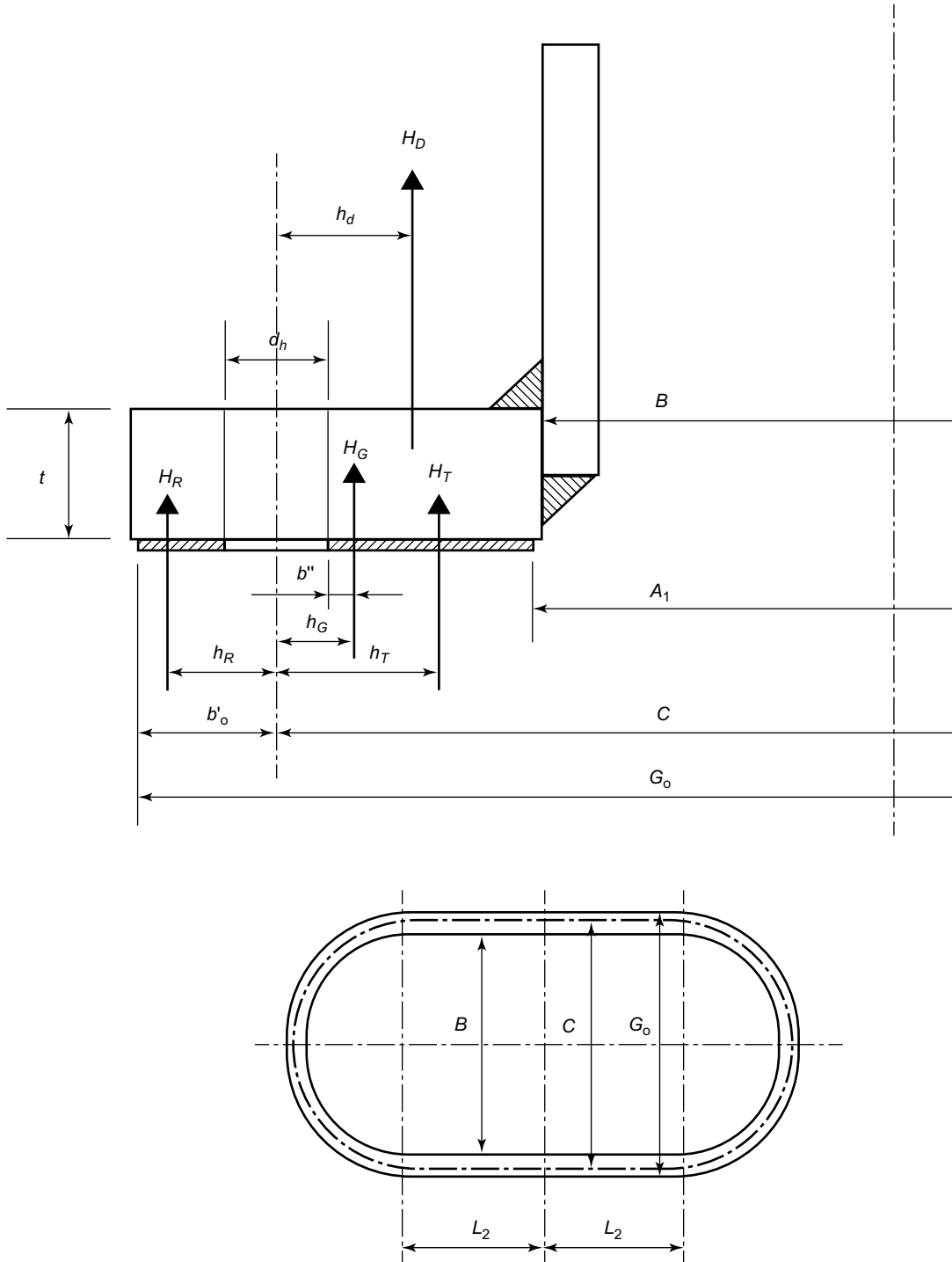


(a)



(b)

Figure 3
Obround Flat Face Flange Geometry



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Case 3085

Use of ASME B31.1, 2020 Edition in Lieu of 2022 Edition for Qualification of NDE Personnel for Visual Examination (VT), Liquid Penetrant Testing (PT), and Magnetic Particle Testing (MT) Required for Boiler External Piping (BEP) on Boilers

Section I

Approval Date: January 23, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may ASME B31.1, 2020 Edition, para. 136.3.2 be used in lieu of ASME B31.1, 2022 Edition, para. 136.3.2 for the qualification of NDE personnel for Visual Examination (VT), Liquid Penetrant Testing (PT), and Magnetic Particle Testing (MT) as required for boiler external piping on Section I boilers?

Reply: It is the opinion of the Committee that ASME B31.1, 2020 Edition, para. 136.3.2 may be used in lieu of ASME B31.1, 2022 Edition, para. 136.3.2 for the qualification of NDE personnel for Visual Examination (VT),

Liquid Penetrant Testing (PT), and Magnetic Particle Testing (MT) as required for boiler external piping on Section I boilers, provided the following requirements are met:

(a) The requirements of ASME B31.1, 2020 Edition, para. 136.3.2 are documented in the Manufacturer's written practice.

(b) The Manufacturer shall have a copy of ASME B31.1, 2020 Edition.

(c) All other requirements of ASME B31.1, 2022 Edition shall be met.

(d) All other requirements of Section I boiler external piping shall be met.

(e) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3086

Use of an Elastic-Plastic Analysis With Material Model in KM-620 for Hydrostatic Test Criteria in KD-236

Section VIII, Division 3

Approval Date: January 8, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may an elastic-plastic analysis with material model in KM-620 be used for the hydrostatic test criteria in KD-236?

Reply: It is the opinion of the Committee that an elastic-plastic analysis with material model in KM-620 may be used for the hydrostatic test criteria in KD-236, provided the following requirements are met:

(a) The load combination to be used with the model in KM-620 shall be in accordance with the equation below in lieu of that given in Table KD-230.4.

$$1.25(P_t + P_s + D + 0.6W_{pt})$$

(b) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3087

Use of UNS S43932 Ferritic Chromium Stainless Steel in SA-268/ SA-268M Seamless and Welded Tube

Section VIII, Division 1

Approval Date: March 28, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may UNS S43932 ferritic chromium stainless steel conforming to SA-268/SA-268M seamless and welded tubing be used under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that UNS S43932 ferritic chromium stainless steel conforming to SA-268/SA-268M seamless and welded tubing may be used in construction of welded pressure vessels under the rules of Part UHA of Section VIII, Division 1, provided the following requirements are met:

(a) For UNS S43932 conforming to SA-268/SA-268M seamless tube, the maximum allowable stress values and Notes, tensile strength values and yield strength values shall be those for 18Cr-Ti, seamless tube, SA-268/SA-268M, UNS S43035 material in Section II, Part D, Table 1A, Table U, and Table Y-1.

(b) For UNS S43932 conforming to SA-268/SA-268M welded tube, the maximum allowable stress values and Notes, tensile strength values and yield strength values

shall be those for 18Cr-Ti, welded tube, SA-268/SA-268M, UNS S43035 material in Section II, Part D, Table 1A, Table U, and Table Y-1.

(c) Welding procedure and performance qualification shall be conducted in accordance with Section IX. Those materials shall be considered P-No. 7, Group No. 2.

(d) The maximum design temperature shall not exceed 600°F (316°C).

(e) For external pressure design, Section II, Part D, Figure CS-2 shall be used.

(f) PWHT is not required if the following requirements are met:

(1) The tube wall thickness at welded joint does not exceed $\frac{3}{8}$ in. (10 mm).

(2) For full penetration welds in butt joint with thickness over $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. (10 mm to 38 mm), preheat of 450°F (230°C) is maintained during welding and the joints are completely radiographed.

(g) All other applicable requirements for ferritic chromium stainless steels in Part UHA shall apply.

(h) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3088

Marking Spring-Actuated Nonreclosing Pressure Relief Devices With ASME Certification Mark and UD Designator

Section VIII, Division 1; Section VIII, Division 2; Section XIII

Approval Date: March 28, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a spring-actuated nonreclosing pressure relief device constructed in accordance with Section XIII, Part 6 be marked with the ASME Certification Mark and UD Designator?

Reply: It is the opinion of the Committee that a spring-actuated nonreclosing pressure relief device constructed in accordance with Section XIII, Part 6 may be marked with

the ASME Certification Mark and UD Designator, provided the following requirements are met:

(a) The spring-actuated nonreclosing pressure relief device shall meet the requirements of Part 6 except it shall be marked in accordance with Section XIII, 5.7.1, 5.7.2(a) through 5.7.2(e), and 5.7.2(g) through 5.7.2(j). Additionally, pilot-operated devices shall be marked in accordance with Section XIII, 3.9(f)(1).

(b) The spring-actuated nonreclosing pressure relief device has been certified for capacity or flow resistance by the Manufacturer per the requirements of Section XIII, 9.7.3, 9.7.4, 9.7.5, 9.7.6, 9.7.7, or 9.8.

(c) This Case number shall be documented on the Certificate of Conformance.

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Case 3089

35Ni-30Fe-27Cr-6.5Mo-N Nickel Alloy, UNS N08935

Section I

Approval Date: July 14, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed 35Ni-30Fe-27Cr-6.5Mo-N (UNS N08935) seamless pipe and tube with the chemical composition conforming to Table 1, the mechanical properties conforming to Table 2 and Table 2M, and otherwise conforming to the respective requirements of SB-163 be used for welded construction under the rules of Section I?

Reply: It is the opinion of the Committee that solution annealed 35Ni-30Fe-27Cr-6.5Mo-N (UNS N08935) seamless pipe and tube as described in the Inquiry may be used in welded construction under the rules of Section I provided the following requirements are met:

(a) The maximum design temperature shall be 1,022°F (550°C).

(b) The material shall be furnished in the annealed condition.

(c) The maximum allowable stress values for the material shall be those given in Tables 3 and 3M.

(d) The yield strength and tensile strength values are shown in Tables 4 and 4M.

(e) Welded fabrication shall conform to the applicable requirements of Section I.

(1) Separate welding procedure and performance qualifications shall be conducted in accordance with Section IX.

(2) Welding electrodes and filler metal shall conform to the requirements of PW-5.4.

(3) Where weld repair of a defect is required, it shall be followed by reexamination as required in PW-11. Where a defect is removed and weld repair is not necessary, care shall be taken to contour the surface so as to eliminate any sharp notches or corners. The contoured surface shall then be reexamined by the same means originally used for locating the defect to be sure it has been completely removed.

(f) Heat treatment after welding or fabrication is neither required nor prohibited. If heat treated, the requirements of (b) shall apply.

(g) The physical properties as follows shall apply:

(1) Density is 0.291 lb/in.³ (8.05 g/cm³).

(2) Thermal expansion is shown in Tables 5 and 5M.

(3) Thermal conductivity and thermal diffusivity are shown in Tables 6 and 6M.

(4) The modulus of elasticity and Poisson's ratio are shown in Tables 7 and 7M.

(h) This Case number shall be shown in the marking and on the certification of the material and on the Manufacturer's Data Report.

CAUTION: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting, and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual coldwork. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

Table 1
Chemical Requirements

Element	Compositional Limit, %
Carbon	0.030 max.
Manganese	1.2 max.
Phosphorous	0.030 max.
Sulfur	0.020 max.
Silicon	0.5 max.
Chromium	26.0–28.0
Nickel	34.0–36.0
Molybdenum	6.1–7.1
Iron	Remainder [Note (1)]
Copper	0.4 max.
Nitrogen	0.25–0.36

NOTE: (1) Element shall be determined arithmetically by difference.

Table 2
Mechanical Test Requirements (Room Temperature)

Tensile Strength, min., ksi	109
Yield Strength, 0.2% offset, min., ksi	62
Elongation, in 2 in., min., %	35

Table 2M
Mechanical Test Requirements (Room Temperature)

Tensile Strength, min., MPa	750
Yield Strength, 0.2% offset, min., MPa	425
Elongation, in 50 mm, min., %	35

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi	Maximum Allowable Stress Values, ksi [Note (1)]
75	31.1	31.1
100	31.1	31.1
200	31.1	31.1
300	29.5	29.5
400	28.5	28.5
500	27.7	27.7
600	26.4	27.2
700	25.4	26.7
800	24.7	26.2
900	24.4	25.5
1,000	24.3	24.6
1,050	24.1 [Note (2)]	24.1 [Note (2)]

NOTES:

- (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
- (2) These values are provided for interpolation purposes only. The maximum use temperature is 1,022°F.

Table 3M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa	Maximum Allowable Stress Values, MPa [Note (1)]
40	215	215
65	215	215
100	213	213
150	203	203
200	197	197
250	192	192
300	185	189
350	178	186
400	172	183
450	169	179
500	168	174
550	168	168

NOTE: (1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66²/₃% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Table 4
Yield Strength, Y-1, and Tensile Strength, U, Values

For Metal Temperature Not Exceeding, °F	Yield Strength Values, ksi [Note (1)]	Tensile Strength Values, ksi [Note (2)]
75	62.0	109.0
100	62.0	109.0
200	51.1	108.8
300	46.6	103.3
400	43.7	99.6
500	41.3	97.1
600	39.7	95.3
700	38.1	93.6
800	37.0	91.8
900	36.5	89.4
1,000	36.5	86.2
1,050	36.4	84.2

NOTES:

- (1) See Section II, Part D, Table Y-1, General Note (b).
- (2) See Section II, Part D, Table U, General Note (b).

Table 4M
Yield Strength, Y-1, and Tensile Strength, U, Values

For Metal Temperature Not Exceeding, °C	Yield Strength Values, MPa [Note (1)]	Tensile Strength Values, MPa [Note (2)]
40	427	751
65	373	751
100	347	744
150	321	711
200	303	688
250	289	672
300	277	660
350	267	649
400	258	639
450	253	626
500	252	610
550	251	588

NOTES:

(1) See Section II, Part D, Table Y-1, General Note (b).

(2) See Section II, Part D, Table U, General Note (b).

Table 5
Thermal Expansion

Temperature Range, °F	Value, in./in./°F × 10 ⁻⁶
86-122	7.28
86-212	7.81
86-302	8.02
86-392	8.15
86-482	8.26
86-572	8.37
86-662	8.47
86-752	8.56
86-842	8.64
86-932	8.71
86-1,022	8.77

Table 5M
Thermal Expansion

Temperature Range, °C	Value, mm/mm/°C × 10 ⁻⁶
30-50	13.1
30-100	14.1
30-150	14.4
30-200	14.7
30-250	14.9
30-300	15.1
30-350	15.2
30-400	15.4
30-450	15.6
30-500	15.7
30-550	15.8

Table 6
Thermal Conductivity and Thermal Diffusivity

Temperature, °F	Thermal Conductivity, Btu/hr-ft-°F	Thermal Diffusivity, ft ² /hr
73	5.84	0.110
122	6.19	0.113
212	6.82	0.120
302	7.40	0.126
392	7.92	0.133
482	8.38	0.138
572	8.90	0.145
662	9.42	0.150
752	9.94	0.157
842	10.5	0.162
932	10.8	0.167
1022	11.2	0.172

Table 6M
Thermal Conductivity and Thermal Diffusivity

Temperature, °C	Thermal Conductivity, W/m°C	Thermal Diffusivity, m ² /s × 10 ⁻⁶
23	10.1	2.83
50	10.7	2.92
100	11.8	3.09
150	12.8	3.26
200	13.7	3.42
250	14.5	3.57
300	15.4	3.73
350	16.3	3.88
400	17.2	4.04
450	18.1	4.18
500	18.7	4.31
550	19.3	4.44

Table 7
Modulus of Elasticity and Poisson's Ratio

Temperature, °F	Modulus of Elasticity, ksi $\times 10^3$	Poisson's Ratio
68	27.8	0.291
122	27.6	0.292
212	27.1	0.294
302	26.6	0.296
392	26.2	0.298
482	25.7	0.300
572	25.2	0.302
662	24.8	0.304
752	24.3	0.306
842	23.8	0.308
932	23.4	0.310
1,022	22.9	0.312

Table 7M
Modulus of Elasticity and Poisson's Ratio

Temperature, °C	Modulus of Elasticity, MPa $\times 10^3$	Poisson's Ratio
20	192	0.291
50	190	0.292
100	187	0.294
150	184	0.296
200	180	0.298
250	177	0.300
300	174	0.302
350	171	0.304
400	168	0.306
450	164	0.308
500	161	0.310
550	158	0.312

Case 3090

Use of Mandatory Appendix 46, 46-4 for Components Made of Cast Ductile Iron SA-395/SA-395M, Grade 60-40-18

Section VIII, Division 1

Approval Date: August 28, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the rules of Section VIII, Division 1, Mandatory Appendix 46, 46-4 be used to design components made of cast ductile iron SA-395/SA-395M, Grade 60-40-18 by means of Design by Analysis?

Reply: It is the opinion of the Committee that the rules of Section VIII, Division 1, Mandatory Appendix 46, 46-4 for Design by Analysis may be used for components made of cast ductile iron SA-395/SA-395M, Grade 60-40-18, provided the following requirements are met:

(a) All requirements of Section VIII, Division 1, Part UCD shall apply.

(b) Referencing Section VIII, Division 2, Part 5, 5.1.2.4, the following material properties shall be used:

(1) Physical properties according to Section II, Part D are as follows:

(-a) Young's modulus: Table TM-1 for ductile cast iron

(-b) Thermal expansion coefficient: Table TE-1 for ductile cast iron

(-c) Thermal conductivity and diffusivity: Table TCD for ductile cast iron

(-d) Density and Poisson's ratio: Table PRD for cast iron

(2) Strength parameters are as follows:

(-a) Allowable Stress: Section VIII, Division 1, Table UCD-23 for Grade 60-40-18 considering the casting quality factor given in UG-24

(-b) For any analysis method requiring tensile and yield curves at temperature, the following values shall be used:

(-1) For tensile strength, see [Tables 1](#) and [1M](#).

(-2) For yield strength, see [Tables 2](#) and [2M](#).

(-c) When applying the elastic-plastic stress analysis method in Section VIII, Division 2, 5.2.4 for cast ductile iron SA-395/SA-395M, Grade 60-40-18, in conjunction with Section VIII, Division 2, Table 5.5, β shall be 5.0.

(3) Monotonic stress-strain curve applies as follows: When using the elastic perfectly plastic and elastic-plastic true stress-strain curve with strain hardening, the parameters for ferritic steel materials in Section VIII, Division 2, Part 5, Table 5.7 shall be used to determine the uniaxial strain limit.

(4) If a Fatigue Analysis Screening is performed in accordance with Section VIII, Division 2, Part 5, 5.5.2, and it indicates a fatigue assessment is required, this Case may not be used.

(5) Fatigue Analysis Screening based on experience with comparable equipment performed in accordance with Section VIII, Division 2, Part 5, 5.5.2.2 is not permitted.

(c) This Case number shall be shown on the Manufacturer's Data Report.

Table 1
Tensile Strength Values, S_u , for Cast Ductile Iron SA-395/SA-395M, Grade 60-40-18

Tensile Strength S_u , ksi (Multiply by 1,000 to Obtain psi), for Metal Temperatures, °F, Not Exceeding						
100	200	300	400	500	600	650
60.0	59.2	57.5	55.5	53.6	52.5	52.3

Table 1M
Tensile Strength Values, S_u , for Cast Ductile Iron SA-395/SA-395M, Grade 60-40-18

Tensile Strength, S_u , MPa (Multiply by 1000 to Obtain kPa), for Metal Temperatures, °C, Not Exceeding							
40	100	150	200	250	300	325	350
414	407	396	384	372	364	361	360

Table 2
**Yield Strength Values S_y , for Cast Ductile Iron SA-395/
 SA-395M, Grade 60-40-18**

Yield Strength, S_y , ksi (Multiply by 1,000 to Obtain psi), for Metal Temperatures, °F, Not Exceeding						
100	200	300	400	500	600	650
40.0	35.3	33.4	32.4	31.7	31.0	30.5

Table 2M
**Yield Strength Values S_y , for Cast Ductile Iron SA-395/
 SA-395M, Grade 60-40-18**

Yield Strength, S_y , MPa (Multiply by 1000 to Obtain kPa), for Metal Temperatures, °C, Not Exceeding									
40	65	100	150	200	250	300	325	350	
275	254	241	230	223	220	215	213	210	

Case 3091

Use of SA-414/SA-414M, 2021 Edition

Section VIII, Division 1

Approval Date: September 19, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the 2021 edition of SA-414/SA-414M be used for Section VIII, Division 1 construction to the 2023 and 2025 Editions?

Reply: It is the opinion of the Committee that the 2021 edition of SA-414/SA-414M may be used for Section VIII, Division 1 construction to the 2023 and 2025 editions, provided the following requirements are met:

(a) All other Code requirements of the applicable Code edition (2023 or 2025) to be used for final certification of the completed pressure vessel shall be met. All Section VIII, Division 1 requirements specifically applicable to SA-414/SA-414M shall be met.

(1) All appropriate property data for SA-414/SA-414M in Section II, Part D shall be used.

(2) The P-No./Group No. assignment for SA-414/SA-414M from Section IX shall be used.

(b) This Case number shall be recorded on the Manufacturer's Data Report.

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Case 3092

Use of ASTM A511/A511M-21a, Austenitic, Austenitic-Ferritic Duplex, Martensitic, and Ferritic Stainless Steel Hollow Bar

Section VIII, Division 1; Section VIII, Division 2

Approval Date: September 19, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May austenitic stainless steel, austenitic-ferritic duplex stainless steel, martensitic stainless steel, and ferritic stainless steel hollow bar conforming to ASTM A511/A511M-21a be used for nonwelded and welded construction under the rules of Section VIII, Divisions 1 and 2?

Reply: It is the opinion of the Committee that austenitic stainless steel, austenitic-ferritic duplex stainless steel, martensitic stainless steel, and ferritic stainless steel hollow bar conforming to ASTM A511/A511M-21a as described in the Inquiry may be used in nonwelded and welded construction under the rules of Section VIII, Divisions 1 and 2, provided the following requirements are met:

(a) The hollow bar conforms to all the requirements for hollow bar as specified in ASTM A511/A511M-21a.

Mechanical tubing conforming to all the requirements for mechanical tubing as specified in ASTM A511/A511M-21a shall not be used. Hollow bar certified to ASTM A511/A511M-21a and this Case shall not be used in lieu of seamless tube or pipe.

(b) A manufacturer's certification shall be furnished to the purchaser stating that material has been manufactured, tested, and inspected in accordance with ASTM A511/A511M-21a, and that the test results on samples meet specification requirements. A report of the test results shall be furnished.

(c) The UNS number shall be listed under the ASME specification cited in [Table 1](#), [Table 2](#), or [Table 3](#).

(d) For the specific hollow bar grade (UNS number), the ASME specification cited in [Table 1](#), [Table 2](#), or [Table 3](#) shall be used to determine the maximum use temperature, the maximum allowable stresses, notes to table, and the external pressure chart.

(e) The maximum design temperature for material shall not exceed that shown in Section II, Part D, Table 1A or Table 1B for Section VIII, Division 1; Table 2A or

Table 2B for Section VIII, Division 2, Class 1; and Table 5A or Table 5B for Section VIII, Division 2, Class 2.

(f) The maximum allowable stress values and notes to table for the material shall be those given in Section II, Part D, Table 1A or Table 1B for Section VIII, Division 1; Table 2A or Table 2B for Section VIII, Division 2, Class 1; and Table 5A or Table 5B for Section VIII, Division 2, Class 2.

(g) For external pressure design, the External Pressure Chart Number given in Section II, Part D, Table 1A or Table 1B shall apply.

(h) Welding procedure and performance qualifications shall be conducted in accordance with Section IX. The UNS numbers listed in [Tables 1](#), [2](#), and [3](#) have P-Number or Group Number assignments in Section IX, Table QW/QB-422.

(i) The tensile strength and yield strength values and physical properties from Section II, Part D shall apply.

(j) For Section VIII, Division 1 construction, the UNS number shall be listed in Table UHA-23 or Table UNF-23.3. For Section VIII, Division 2 construction, the UNS number shall be listed in Table 3-A.3 or Table 3-A.6.

(k) For Division 2 fatigue analysis, the austenitic and austenitic-ferritic duplex stainless steels shall be considered Figure 3-F.3 or 3-F.3M material. For Division 2, Class 2 fatigue analysis, the martensitic and ferritic stainless steels shall be considered Figure 3-F.1 or 3-F.1M material.

(l) Except for UNS N08020, UNS N08367, UNS N08800, UNS N08810, UNS N08811, UNS N08904, and UNS N08925, the applicable rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UHA for austenitic stainless steels, austenitic-ferritic duplex stainless steels, martensitic stainless steels, or ferritic stainless steels. For Section VIII, Division 2 application, the applicable rules for austenitic stainless steels, austenitic-ferritic duplex stainless steels, martensitic stainless steels, or ferritic stainless steels shall apply except for UNS N08020, UNS N08367, UNS N08800, UNS N08810, UNS N08811, UNS N08904, and UNS N08925.

(m) For UNS N08020, UNS N08367, UNS N08800, UNS N08810, UNS N08811, UNS N08904, and UNS N08925, the rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for nickel alloys. For Section VIII, Division 2 applications, the rules for nickel alloys shall apply to UNS N08020, UNS N08367,

UNS N08800, UNS N08810, UNS N08811, UNS N08904, and UNS N08925.

(n) The applicable rules for rods and bars in Section VIII, Division 1, UG-14 shall apply. For Section VIII, Division 2 applications, the applicable rules for rods and bars in 3.2.5.2 shall apply.

(o) This Case number shall be shown in the marking and on the certification of the material and on the Manufacturer’s Data Report.

Table 1
Austenitic Stainless Steels and Their Applicable ASME Specification Reference for Section II, Part D Tables

Grade	UNS Number	ASME Specification [Note (1)]
XM-19	S20910	SA-213
MT 302	S30200	SA-479
MT 304	S30400	SA-213
MT 304L	S30403	SA-213
MT 305	S30500	SA-240
MT 309S	S30908	SA-213
MT 310S	S31008	SA-213
MT 316	S31600	SA-213
MT 316L	S31603	SA-213
MT 317	S31700	SA-312 (Smls)
MT 321	S32100	SA-213
MT 347	S34700	SA-213
...	N08020	SB-729
...	N08367	SB-690
...	N08800	SB-163
...	N08810	SB-163
...	N08811	SB-163
...	N08904	SB-677
...	N08925	SB-677

NOTE: (1) The specification shall be used in conjunction with the associated UNS number for the requirements; see paras. (d) and (i).

Table 2
Austenitic-Ferritic Duplex Stainless Steels and Their Applicable ASME Specification Reference for Section II, Part D Tables

UNS Number	ASME Specification [Note (1)]
S31260	SA-789 (Smls)
S31803	SA-789 (Smls)
S32101	SA-789 (Smls)
S32205	SA-789 (Smls)
S32304	SA-789 (Smls)
S32506	SA-789 (Smls)
S32550	SA-789 (Smls)
S32750	SA-789 (Smls)
S32760	SA-789 (Smls)
S32906	SA-789 (Smls)
S32950	SA-789 (Smls)
S39274	SA-789 (Smls)

NOTE: (1) The specification shall be used in conjunction with the associated UNS number for the requirements; see paras. (d) and (i).

Table 3
Martensitic and Ferritic Stainless Steels and Their Applicable ASME Specification Reference for Section II, Part D Tables

Grade	UNS Number	ASME Specification [Note (1)]
Martensitic Stainless Steels		
MT 410	S41000	SA-268 (Smls)
Ferritic Stainless Steels		
MT 405	S40500	SA-268 (Smls)
MT 429	S42900	SA-268 (Smls)
MT 430	S43000	SA-268 (Smls)
MT 446-1	S44600	SA-268 (Smls)
29-4	S44700	SA-479
29-4-2	S44800	SA-479

NOTE: (1) The specification shall be used in conjunction with the associated UNS number for the requirements; see paras. (d) and (i).

Case 3093

Alternative Weld Material Properties Requirements, KM-243

Section VIII, Division 3

Approval Date: September 19, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible for the weld material mechanical properties (yield and tensile strength) to be lower than those required in the base material specification as required in KM-243?

Reply: It is the opinion of the Committee that it is permissible for the weld material mechanical properties (yield and tensile strength) to be lower than those required in the base material specification as required in KM-243, provided that all of the following requirements are met:

(a) The base material specification shall have a specified minimum yield strength greater than or equal to 100 ksi (690 MPa).

(b) Weld material properties are only permitted to be lower than the base material specification for Category B weld joints as defined in KE-321.

(c) The weld material yield strength and tensile strength test results are the only properties permitted to be below the base material specification and are only permitted to be a maximum of 10% below the base material specification minimums.

(d) The User shall state that the use of this Case is acceptable in their User's Design Specification.

(e) The Manufacturer's Design Report shall demonstrate the acceptability of the design to meet the requirements of Section VIII, Division 3 and the User's Design Specification considering the lower yield and tensile strength in the welds. The properties of tensile strength, yield strength, and reduction of area obtained by mechanical test for weld shall be used for design analysis of welded joint.

(f) The required Charpy V-notch absorbed energy and fracture toughness in all parts of the vessel shall be met.

(g) This Case number shall be listed on the Manufacturer's Data Report.

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Case 3094

Microchannel Heat Exchangers Fabricated Using Diffusion Welded Plate Packs

(25)

Section VIII, Division 1

Approval Date: November 23, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what alternatives to the existing rules of Section VIII, Division 1 may microchannel heat exchangers be fabricated using diffusion welded plate packs?

Reply: It is the opinion of the Committee that microchannel heat exchangers may be fabricated using diffusion welded plate packs, provided the following requirements are met:

(a) The diffusion welds in the plate packs shall be considered uncategorized in lieu of the existing rules of UW-3(c).

(b) Welds attaching inlet and outlet channel headers shall be considered Category D under the rules of UW-3(d).

(c) The ultrasonic examinations currently specified by UW-55(a)(2) are not required.

(d) This Case number shall appear on the Manufacturer's Data Report.

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Case 3095

Post-Hydrotest Welding of Nonpressure Parts to Pressure Parts (25)

Section IV

Approval Date: December 2, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible to weld nonpressure parts to pressure parts after the hydrotest is completed for hot water heating boilers (H) and water heaters (HLW) using materials not already permitted by HW-840 and HLW-454?

Reply: It is the opinion of the Committee that it is permissible to weld nonpressure parts to pressure parts after the hydrotest is completed for hot water heating boilers (H) and water heaters (HLW) using materials not already permitted by HW-840 and HLW-454, provided the following criteria are met:

(a) The weld qualification is done in accordance with Section IX.

(b) The welding is performed according to Section IV.

(c) The additional pressure part and nonpressure part material is limited to P-No. 8, Group No. 1 material listed in Section II, Part D, Tables 6A and 6D.

(d) The attachment is done by fillet welds where the throat of the weld is not to exceed the lesser of $1.5t_{\min}$ or $\frac{1}{4}$ in. (6 mm).

NOTE: t_{\min} the thickness of the thinner of the parts joined.

(e) The completed weld is inspected by the Authorized Inspector.

(f) The Manufacturer's Data Report Form shall be signed only after completion of the welding.

(g) All other requirements of Section IV shall be met.

(h) This Case number shall be shown on Manufacturer's Data Report.

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Case 3096

Use of Ultrasonic Examination in Lieu of Radiography for Thicknesses Greater Than or Equal to 4.40 mm (0.173 in.) and Less Than 6.0 mm (0.25 in.)

(25)

Section VIII, Division 1; Section VIII, Division 2

Approval Date: December 4, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions and limitations may an ultrasonic examination be used in lieu of radiography, when radiography is required in accordance with Section VIII, Division 1, UW-11(a) and Section VIII, Division 2, Table 7.3 for welds with thicknesses greater than or equal to 4.40 mm (0.173 in.) and less than 6.0 mm (0.25 in.)?

Reply: It is the opinion of the Committee that all welds greater than or equal to 4.40 mm (0.173 in.) and less than 6.0 mm (0.25 in.) in thickness in pressure vessels may be examined using the ultrasonic (UT) method in lieu of the radiographic (RT) method, provided the following requirements are met:

(a) The requirements of Section VIII, Division 2, 7.5.5 shall be followed where applicable.

(b) A documented scan plan for each weld that provides a standardized and repeatable methodology for weld acceptance shall be developed and shall include the following:

- (1) transducer placement
- (2) transducer movement
- (3) component coverage
- (4) ultrasonic beam angle used
- (5) beam directions with respect to weld centerline and weld volume examined

(c) The documentation of the examination strategy or scan plan shall be made available to the Authorized Inspector upon request.

(d) The ultrasonic examination shall be performed in accordance with a written procedure conforming to the requirements of Section V, Article 4, Mandatory Appendix VIII. The demonstration block used for qualification of the procedure as required in Section V, Article 4, Mandatory Appendix VIII, VIII-421 and Mandatory Appendix IX may be prepared by welding or the hot isostatic pressing process (HIP). The demonstration block shall contain a minimum of three flaws, oriented to simulate flaws parallel to the production weld's fusion line as follows:

(1) one surface flaw on the side of the block representing the vessel O.D. surface.

(2) one surface flaw on the side of the block representing the vessel I.D. surface.

(3) one subsurface flaw.

(4) if the block can be flipped during UT examination, then one flaw may represent both the I.D. and O.D. surfaces. If the block is flipped, only two flaws (one surface flaw and one subsurface flaw) may be required.

Flaw size shall be no larger than the flaw in [Table 1](#) for the thickness to be examined.

(e) All other applicable requirements from the code of construction shall be followed including Section VIII, Division 1, UW-53 and Section VIII, Division 2, Part 7.

(f) This Case number shall be noted on the Manufacturer's Data Report.

Table 1
Flaw Acceptance Criteria for Welds With a Thickness Equal to or Greater Than 4.4 mm (0.173 in.) and Thickness Less Than 6 mm (1/4 in.)

Thickness, <i>t</i> , mm (in.)	<i>a</i> , mm (in.)		<i>l</i> , mm (in.)
	Surface	Subsurface	
4.40 (0.173)	0.61 (0.024)	0.30 (0.012)	≤ 3.4 (≤ 0.135)
6 (1/4)	0.95 (0.040)	0.48 (0.020)	≤ 6.4 (≤ 1/4)

GENERAL NOTES:

- (a) The parameter *t* is the thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, *t* is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, then the thickness of the throat of the fillet weld shall be included in *t*.
- (b) *a* and *l* are as defined in Section VIII, Division 2, 7.5.5.2.
- (c) The criteria for <6 mm (<1/4 in.) is for interpolation of intermediate thicknesses only. For intermediate thicknesses [4.40 mm (0.173 in.) ≤ *t* < 6 mm (1/4 in.)], linear interpolation is permissible. See Section VIII, Division 2, Table 7.8 for 6 mm (1/4 in.) thickness.
- (d) A subsurface indication shall be considered a surface flaw if the separation (*S* in Section VIII, Division 2, Figure 7.11) of the indication from the nearest surface of the component is equal to or less than half the through dimension [*2d* in Section VIII, Division 2, Figure 7.11, illustration (b)] of the subsurface indication.

Case 3097

Use of Alternative Base Metal in Clad Construction

(25)

Section VIII, Division 1

Approval Date: December 9, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a base material not currently referenced in Section VIII, Division 1, UCL-10 be used in clad construction?

Reply: It is the opinion of the Committee that a base material not currently referenced in UCL-10 may be used in clad construction, provided all the following conditions are met:

(a) The base material shall meet the requirements of UG-4(a).

(b) This Case number shall be shown in the Manufacturer's Data Report.

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Case 3098

Hydraulic Proof Pressure Test and Hydraulic Volumetric Expansion Test

(25)

Section X

Approval Date: December 6, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions and requirements may the hydraulic proof pressure test and hydraulic volumetric expansion test be conducted at a pressure greater than or equal to 1.25 times the design pressure and used to demonstrate compliance with the User's Design Specification cycle requirements under the rules of Section X, Mandatory Appendix 8 for Class III vessels with nonload-sharing liners?

Reply: It is the opinion of the Committee that a Class III composite pressure vessel shall be subjected to a hydraulic proof pressure test as required by Section X, Mandatory Appendix 8, 8-700.5.1, and a hydraulic volumetric expansion test as required by Section X, Mandatory Appendix 8, 8-700.5.2, where the hydraulic pressure is at least 1.25 times design pressure, but no more than 1.5 times design pressure, so as to be in compliance with the User's Design Specification.

This Case number shall be recorded on the Fabricator's Data Report, Form CPV-1.

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Case 3099

Use of Fine Grain Low-Carbon Stainless Steels to Make Diffusion Welded Components for Service Above 1,000°F (540°C) (25)

Section VIII, Division 1; Section VIII, Division 2

Approval Date: December 4, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may L grade stainless steel with a grain size finer than ASTM No. 7 be used to make diffusion welded components for service above 1,000°F (540°C) in lieu of the requirements of SA-240/SA-240M, para. 6.2 and supplementary requirement S2.3?

Reply: It is the opinion of the committee that L grade stainless steel with a grain size finer than ASTM No. 7 may be used to make diffusion welded components for service above 1,000°F (540°C) in lieu of the requirements of SA-240/SA-240M, para. 6.2 and supplementary requirement S2.3, provided the following requirements are met:

(a) The Manufacturer has performed a one-time demonstration that the final grain size after diffusion welding shall be ASTM No. 7 or coarser.

(1) The test assembly shall be that specified in Section IX, QW-185. It shall be made from the same material grade as that to be used in production and shall have the smallest grain size as the material to be used in production.

(2) That test assembly shall be heat treated for the minimum time at the minimum temperature that will be used in production welding.

(3) The test specimen shall be metallographically examined and show that a grain size ASTM No. 7 or coarser was achieved.

(4) A demonstration report documenting the performance of this test and its results shall be prepared by the Manufacturer.

(b) The material grade, the lower limit on grain size, the minimum welding temperature, and the minimum welding time established by (a) shall be observed by the Manufacturer when diffusion welding components.

(c) The demonstration report shall be part of the documentation presented to the Authorized Inspector.

(d) This Case number shall be shown on the Manufacturer's Data Report.

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Case 3100

Alternative Requirements for Pressure Vessel Designers

(25)

Section VIII, Division 1

Approval Date: December 10, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In lieu of the requirements of Mandatory Appendix 47 in Section VIII, Division 1, 2023 edition, what alternative requirements may be used for pressure vessel designers?

Reply: It is the opinion of the Committee that in lieu of the requirements of Mandatory Appendix 47 in Section VIII, Division 1, 2023 edition, the following alternative requirements may be used for pressure vessel designers:

(a) General Requirements

(1) The Manufacturer shall designate one or more persons to perform design work or exercise control of design work performed by others.

(2) The scope of design work includes all work performed in accordance with the rules of Division 1 or performed under U-2(g) where methods outside the rules of Division 1 may be applied.

(3) All design work shall be in accordance with the Manufacturer's Quality Control System.

(4) Additional requirements or qualifications specified by the User or Jurisdiction are outside the scope of this Case.

(5) As an alternative to the requirements in this Case, Manufacturers may follow the requirements of Section VIII, Division 2, Part 2.

(b) Manufacturer's Responsibilities

(1) The Manufacturer who engages a designer by direct employ, contract, or agreement shall maintain a controlled document, referenced in the Quality Control System in accordance with Mandatory Appendix 10, that describes the minimum qualifications and evidence of meeting the qualifications for persons performing design work for the Manufacturer's products.

(2) The Manufacturer who engages a designer by contract or agreement shall maintain a controlled document, referenced in the Quality Control System, that identifies the following:

(-a) the process by which the Manufacturer ensures the design is in compliance with the Quality Control System

(-b) the person or persons in the Manufacturer's organization exercising control of design work performed by others

(-c) the process by which design activities performed by others are accepted by the Manufacturer [see U-2(b)(2)]

(3) The Manufacturer shall maintain a documented list of qualified designers for the Manufacturer's products.

(4) The Manufacturer shall review and document the minimum qualifications of designers every three years or whenever the required design qualifications for the Manufacturer's products are modified.

(c) Designer's Responsibilities

(1) Designers engaged in design work by direct employ, contract, or agreement shall be qualified to meet the following minimum requirements established by the Manufacturer as described in the Quality Control System (see Mandatory Appendix 10):

(-a) have knowledge of and perform design work in accordance with the Manufacturer's or Assembler's quality program

(-b) have knowledge of the design requirements of Section VIII, Division 1 for the application of the Certification Mark with the appropriate Designator

(-c) satisfy and demonstrate the minimum qualifications for design of the Manufacturer's or Assembler's products

(d) This Case number shall be recorded on the Manufacturer's Data Report.

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Case 3101

Use of Fatigue Evaluation Using Elastic–Plastic Analysis and Equivalent Strain Ranges

(25)

Section VIII, Division 2; Section VIII, Division 3

Approval Date: December 4, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may the fatigue evaluation using elastic–plastic analysis and equivalent strain ranges in Section VIII, Division 2, 5.5.4 be used for nonwelded locations of carbon or low alloy steels, series 3xx high alloy steels, steel bolting, and aluminum in lieu of the fatigue evaluation in KD-310 for Section VIII, Division 3 construction?

Reply: It is the opinion of the Committee that the fatigue evaluation procedure using elastic–plastic analysis and equivalent strain ranges in Section VIII, Division 2, 5.5.4 may be used for nonwelded locations of carbon or low alloy steels, series 3xx high alloy steels, steel

bolting, and aluminum in lieu of the fatigue evaluation procedure in KD-310 for Section VIII, Division 3 construction, provided the following requirements are met:

(a) The design fatigue curves in Figure KD-320.2 (Figure KD-320.2M), Figure KD-320.3 (Figure KD-320.3M), Figure KD-320.5 (Figure KD-320.5M), or Figure KD-320.7 (Figure KD-320.7M) in KD-322 of Section VIII Division 3, as applicable, shall be used. The surface roughness factor and mean stress correction do not need to be applied.

(b) The effective strain range shall be calculated for each cycle in the loading histogram using cycle-by-cycle analysis. Twice Yield Method in Section VIII, Division 2, 5.5.4.1(b) shall not be used.

(c) Operating pressure shall not exceed 10,000 psi (68.95 MPa).

(d) This Case number shall be recorded on the Manufacturer's Data Report.

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Case 3102

Use of Welding Research Council (WRC) Bulletin 503 “Compendium of Temperature-Dependent Physical Properties for Pressure Vessel, Piping and Tankage Materials” as Alternative to Section II, Part D, Subpart 2 Physical Properties (25)

Section VIII, Division 2

Approval Date: December 4, 2024

Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In lieu of Section II, Part D, Subpart 2 physical properties as required by Section VIII, Division 2, 3.14, may WRC Bulletin 503, “Compendium of Temperature-Dependent Physical Properties for Pressure Vessel, Piping and Tankage Materials” (second edition, June 2023) be used as the data source for physical properties for the materials listed in the bulletin in the construction of Section VIII, Division 2 vessels?

Reply: It is the opinion of the Committee that in lieu of Section II, Part D, Subpart 2 physical properties as required by Section VIII, Division 2, 3.14, WRC Bulletin

503 “Compendium of Temperature-Dependent Physical Properties for Pressure Vessel, Piping and Tankage Materials” (second edition, June 2023) may be used as the data source for physical properties for the materials listed in the bulletin in the construction of Section VIII, Division 2 vessels, provided the following requirements are met:

(a) When calculating the thermal diffusivity above 1,000°F (540°C) for UNS N07718 or UNS N10003, the calculated values shall be verified to be within 10% of the values provided in Section II, Part D, Subpart 2. Otherwise, the values provided in Section II, Part D, Subpart 2 shall be used.

(b) This Case number shall be shown in the Manufacturer’s Data Report.

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AN INTERNATIONAL CODE

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