ASME BPVC.CC.BPV-2025

CODE CASES

2025 ASME Boiler and Pressure Vessel Code

An International Code

Boilers and Pressure Vessels

ASME
SETTING THE STANDARD

Markings such as "ASME," "ASME Standard," or any other marking including "ASME," ASME logos, or the ASME Single Certification Mark shall not be used on any item that is not constructed in accordance with all of the applicable requirements of the Code or Standard. Use of the ASME Single Certification Mark requires formal ASME certification; if no certification program is available, such ASME markings may not be used. (For Certification and Accreditation Programs, see https://www.asme.org/certification-accreditation.)

Items produced by parties not formally possessing an ASME Certificate may not be described, either explicitly or implicitly, as ASME certified or approved in any code forms or other document.

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

This international code or standard was developed under procedures accredited as meeting the criteria for American National Standards and it is an American National Standard. The standards committee that approved the code or standard was balanced to ensure that individuals from competent and concerned interests had an opportunity to participate. The proposed code or standard was made available for public review and comment, which provided an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large

ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity. ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor does ASME assume any such liability. Users of a code or standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility

Participation by federal agency representatives or persons affiliated with industry is not to be interpreted as government or industry endorsement of this code or standard.

ASME accepts responsibility for only those interpretations of this document issued in accordance with the established ASME procedures and policies, which precludes the issuance of interpretations by individuals.

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

ASME Collective Membership Mark

ASME Single Certification Mark

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

TABLE OF CONTENTS

(25)

LIST OF SECTIONS

SECTIONS

I Rules for Construction of Power Boilers

II Materials
- Part A — Ferrous Material Specifications
- Part B — Nonferrous Material Specifications
- Part C — Specifications for Welding Rods, Electrodes, and Filler Metals
- Part D — Properties (Customary)
- Part D — Properties (Metric)

III Rules for Construction of Nuclear Facility Components
- Subsection NCA — General Requirements for Division 1 and Division 2
- Appendices
- Division 1
  - Subsection NB — Class 1 Components
  - Subsection NCD — Class 2 and Class 3 Components
  - Subsection NE — Class MC Components
  - Subsection NF — Supports
  - Subsection NG — Core Support Structures
- Division 2 — Code for Concrete Containments
- Division 3 — Containment Systems for Transportation and Storage of Spent Nuclear Fuel and High-Level Radioactive Material
- Division 4 — Fusion Energy Devices
- Division 5 — High Temperature Reactors

IV Rules for Construction of Heating Boilers

V Nondestructive Examination

VI Recommended Rules for the Care and Operation of Heating Boilers

VII Recommended Guidelines for the Care of Power Boilers

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

IX Welding, Brazing, and Fusing Qualifications

X Fiber-Reinforced Plastic Pressure Vessels

XI Rules for Inservice Inspection of Nuclear Reactor Facility Components
- Division 1 — Rules for Inservice Inspection of Nuclear Power Plant Components
- Division 2 — Requirements for Reliability and Integrity Management (RIM) Programs for Nuclear Reactor Facilities

XII Rules for Construction and Continued Service of Transport Tanks

XIII Rules for Overpressure Protection

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/CSCommittees.

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.

Page	***Location***	***Change***
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 alphanumerical 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

(25)

NUMERIC INDEX

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
1325-18	6-23-2005	...	...	...
1750-32	2-3-2025	...	...	1750-31
1827-3	12-30-2006	...	...	...
1849-1	8-4-2004	...	...	...
1855-2	12-18-2018	...	...	...
1876-6	3-4-2024	...	...	...
1924-2	12-30-2006	...	...	...
1932-5	8-4-2006	...	...	...
1934	5-25-1983	...	...	...
1935-4	9-23-2007	...	...	...
1936-3	2-20-2002	...	...	...
1949-4	2-20-2004	...	...	...
1968-1	12-2-1990	...	...	...
1993-7	10-26-2016	...	...	...
2016-1	8-12-1996	...	...	...
2038-5	2-7-2000	...	...	...
2055-2	5-4-1999	...	...	...
2063-6	10-2-2008	...	...	...
2073-1	10-29-1999	...	...	...
2093	6-19-1990	...	...	...
2120-1	10-29-1999	...	...	...
2127-3	9-18-2006	...	...	...
2142-6	8-1-2018	...	...	...
2143-2	4-1-2014	...	...	...
2146	11-25-1992	...	...	...
2150	8-12-1993	...	...	...
2151-3	9-30-2018	...	...	...
2172	8-8-1994	...	...	...
2179-12	5-12-2024	...	...	...
2180-9	2-3-2025	...	...	2180-8
2192-11	10-4-2023	...	...	...
2195-1	2-7-2000	...	...	...
2196-5	4-2-2020	...	...	...
2197-1	2-17-2000	...	...	...
2199-10	5-12-2024	...	...	...
2203-2	12-7-2022	...	...	...
2205	6-5-1995	...	...	...
2217-5	6-17-2003	...	...	...
2222-2	10-29-1999	...	...	...
2223-3	6-20-2002	...	1-1-2026	...
2224-2	9-18-2006	...	...	...
2226-2	5-21-2003	...	...	...
2230-2	10-29-1999	...	...	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
2239-1	10-29-1999	...	...	...
2244-2	1-20-2000	...	...	...
2247	7-9-1998	...	...	...
2249	8-11-1997	...	...	...
2254-1	4-2-2020	...	1-1-2026	...
2260-3	12-2-2019	...	...	...
2276-1	2-17-2000	...	...	...
2286-6	10-30-2015	...	...	...
2297	11-30-1999	...	...	...
2300	9-23-1999	...	...	...
2304-2	5-12-2004	...	...	...
2305-1	12-14-2009	...	...	...
2318	9-23-1999	...	...	...
2321-1	2-20-2002	...	...	...
2324-1	3-21-2012	...	...	...
2327-4	2-3-2025	...	...	2327-3
2334	7-10-2000	...	...	...
2346-1	2-14-2003	...	...	...
2350	2-26-2001	...	...	...
2351-1	11-30-2017	...	...	...
2353-2	4-23-2023	...	...	...
2357-2	12-30-2006	...	...	...
2359-2	6-23-2005	...	...	...
2377	1-27-2003	...	...	...
2385-1	5-4-2004	...	...	...
2397-2	8-30-2022	...	...	...
2400	2-14-2003	...	...	...
2402-1	9-25-2012	...	...	...
2403	2-13-2003	...	10-1-2025	...
2407	2-13-2003	...	...	...
2411	6-23-2005	...	...	...
2416	2-13-2003	...	...	...
2418-2	6-23-2014	...	...	...
2419	5-21-2003	...	...	...
2421	5-21-2003	...	...	...
2426	1-27-2003	...	...	...
2427	5-21-2003	...	...	...
2428-4	4-17-2020	...	...	...
2430	1-12-2005	...	...	...
2432-1	6-20-2008	...	...	...
2439	2-14-2003	...	...	...
2440-1	11-10-2024	...	...	2440
2445-2	6-25-2010	...	...	...
2446-1	11-10-2024	...	...	2446
2458-3	1-22-2007	...	...	...
2461-2	9-12-2017	...	...	...
2463-1	9-8-2010	...	...	...
2468-3	3-13-2020	...	...	...
2469-1	10-21-2009	...	...	...
2473-2	12-18-2018	...	...	...
2475	11-29-2004	...	...	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
2478-1	3-13-2019	...	...	...
2481-1	11-17-2016	...	...	...
2489	2-22-2005	...	...	...
2493-1	9-12-2017	...	...	...
2494-2	3-28-2017	...	...	...
2496-4	9-30-2018	...	...	...
2498	6-20-2008	...	...	...
2500	11-2-2004	...	...	...
2511	8-3-2005	...	...	...
2512	10-27-2005	...	...	...
2514-1	7-7-2006	...	...	...
2516	8-3-2005	...	1-1-2026	...
2518-2	12-8-2014	...	...	...
2520	8-4-2006	...	...	...
2527	4-26-2007	...	...	...
2529	10-27-2005	...	...	...
2537	10-27-2005	...	...	...
2538	1-19-2006	...	...	...
2540-2	5-12-2024	...	...	...
2544-2	1-26-2009	...	...	...
2554	1-3-2006	...	...	...
2556-2	9-15-2009	...	...	...
2563	12-30-2006	...	...	...
2565	12-30-2006	...	...	...
2568-1	R12-21-2016	...	...	...
2571-1	1-26-2009	...	1-1-2024	...
2576	12-30-2006	...	...	...
2577	10-2-2008	...	...	...
2581	4-26-2007	...	...	...
2585-1	9-15-2009	...	1-1-2026	...
2587	8-6-2007	...	...	...
2588	10-19-2007	...	...	...
2594-2	9-30-2018	...	...	...
2595	1-4-2008	...	...	...
2596-1	4-6-2011	...	...	...
2597	5-21-2008	...	...	...
2598	1-29-2008	...	...	...
2603-2	4-15-2017	...	...	...
2604	10-2-2008	...	...	...
2605-4	7-24-2019	...	...	...
2606	1-26-2009	...	...	...
2607	1-26-2009	...	...	...
2608	1-26-2009	...	...	...
2609	1-26-2009	...	...	...
2610	1-26-2009	...	...	...
2611	1-26-2009	...	...	...
2613	1-30-2009	...	...	...
2616-1	9-23-2013	...	...	...
2617	5-9-2009	...	...	...
2618	7-5-2009	...	...	...
2619	6-24-2009	...	...	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
2620-3	10-6-2019	...	...	...
2624-1	12-2-2019	...	...	...
2627	9-30-2009	...	...	...
2628	9-30-2009	...	1-1-2026	...
2629	1-13-2010	...	...	...
2630	1-13-2010	...	...	...
2631	12-14-2009	...	...	...
2632	10-21-2009	...	...	...
2634	12-14-2009	...	...	...
2636	1-13-2010	...	...	...
2639	1-20-2010	...	...	...
2640-1	1-20-2011	...	...	...
2641	12-14-2009	...	...	...
2643-1	10-6-2019	...	...	...
2645	3-10-2010	...	...	...
2649	7-2-2010	...	...	...
2652-1	6-23-2014	...	...	...
2653-1	3-5-2018	...	...	...
2655-1	1-8-2024	...	...	...
2658	9-8-2010	...	...	...
2659	9-8-2010	...	...	...
2660	9-8-2010	...	...	...
2661-2	4-23-2019	...	...	...
2663	12-7-2010	...	...	...
2665-1	7-13-2011	...	...	...
2666	1-12-2011	...	...	...
2668-1	1-31-2017	...	...	...
2671-2	12-18-2018	...	...	...
2672	6-16-2011	...	...	...
2673	6-16-2011	...	...	...
2674-1	9-30-2018	...	...	...
2675-1	8-30-2022	...	...	...
2676	6-16-2011	...	...	...
2677	4-6-2011	...	...	...
2678-1	9-26-2011	...	...	...
2679	6-16-2011	...	...	...
2680	6-16-2011	...	...	...
2681-1	9-30-2018	...	...	...
2682	7-13-2011	...	...	...
2683	7-13-2011	...	...	...
2684-5	8-1-2018	...	...	...
2686	8-5-2011	...	...	...
2687-1	12-18-2017	...	...	...
2688	8-19-2011	...	...	...
2690-1	10-2-2014	...	...	...
2692-1	2-3-2025	...	...	2692
2693-1	4-4-2012	...	...	...
2694	9-26-2011	...	...	...
2696	7-13-2011	...	...	...
2697-1	8-1-2016	...	...	...
2698-2	4-2-2020	...	1-1-2026	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
2701-2	4-16-2024	...	...	...
2702-8	1-27-2024	...	...	...
2703-1	8-1-2018	...	...	...
2704	9-26-2011	...	...	...
2705	8-9-2011	...	...	...
2706	11-7-2011	...	...	...
2707	11-7-2011	...	...	...
2708	11-7-2011	...	...	...
2711-1	9-30-2018	...	...	...
2712-2	1-24-2022	...	...	...
2715	2-13-2012	...	...	...
2718	3-21-2012	...	...	...
2719	4-4-2012	...	...	...
2720	4-4-2012	...	...	...
2721	4-4-2012	...	...	...
2722-1	10-25-2012	...	...	...
2723	4-4-2012	...	...	...
2724	4-4-2012	...	...	...
2725-1	10-6-2020	...	...	...
2726	5-24-2012	...	...	...
2727-1	9-30-2018	...	...	...
2728-1	9-30-2018	...	...	...
2729-2	4-3-2019	...	...	...
2730	6-28-2012	...	...	...
2731	5-16-2012	...	...	...
2733-3	8-1-2018	...	...	...
2734-3	8-1-2018	...	...	...
2735	9-25-2012	...	...	...
2736-2	6-23-2014	...	...	...
2737-2	9-30-2018	...	...	...
2738	9-25-2012	...	...	...
2739	9-25-2012	...	...	...
2740-1	9-30-2018	...	...	...
2741	8-15-2012	...	...	...
2742	8-29-2012	...	...	...
2743	8-29-2012	...	...	...
2744	8-29-2012	...	...	...
2745-1	7-29-2014	...	...	...
2746	8-29-2012	...	...	...
2747	8-29-2012	...	...	...
2748-2	9-30-2018	...	...	...
2749-2	9-30-2018	...	...	...
2750	12-12-2012	...	...	...
2751	12-12-2012	...	...	...
2752-1	5-30-2019	...	...	...
2753-1	3-13-2019	...	...	...
2754	12-12-2012	...	...	...
2755	12-18-2012	...	...	...
2756	1-7-2013	...	...	...
2757-2	7-15-2021	...	...	...
2758	1-10-2013	...	...	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
2759	1-10-2013	...	...	...
2760-1	12-12-2019	...	...	...
2761-1	11-7-2017	...	...	...
2763-2	11-29-2022	...	...	...
2765-2	1-8-2024	...	...	...
2767	6-18-2013	...	...	...
2770-1	11-2-2021	...	...	...
2771	6-18-2013	...	...	...
2772	6-18-2013	...	...	...
2773	8-27-2013	...	...	...
2774	9-18-2013	...	...	...
2775	9-18-2013	...	...	...
2776	9-18-2013	...	...	...
2777-1	9-30-2018	...	...	...
2778	9-18-2013	...	...	...
2779	9-18-2013	...	...	...
2780-1	6-1-2015	...	...	...
2781-3	5-12-2024	...	...	...
2782	10-23-2013	...	...	...
2783	9-28-2013	...	...	...
2784	11-1-2013	...	...	...
2786	11-1-2013	...	...	...
2787-2	9-19-2024	...	...	...
2789-1	9-19-2022	...	...	...
2790	11-1-2013	...	...	...
2791	1-6-2014	...	...	...
2792	1-23-2014	...	...	...
2793	3-18-2014	...	...	...
2794	3-18-2014	...	...	...
2795	3-18-2014	...	...	...
2797	3-18-2014	...	1-1-2026	...
2798	4-1-2014	...	...	...
2799-1	6-26-2018	...	...	...
2801-2	1-8-2024	...	...	...
2802-2	1-8-2024	...	...	...
2803	5-19-2014	...	...	...
2804	6-23-2014	...	...	...
2805	5-14-2014	...	...	...
2806	6-23-2014	...	...	...
2807-1	12-30-2018	...	...	...
2808-1	4-29-2022	...	...	...
2809	10-2-2014	...	...	...
2810	10-2-2014	...	...	...
2811	11-14-2014	...	...	...
2812	12-31-2014	...	...	...
2813	1-12-2015	...	...	...
2814	1-8-2015	...	...	...
2815-1	9-30-2018	...	...	...
2816	1-8-2015	...	...	...
2817	1-8-2015	...	...	...
2820	11-29-2014	...	...	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
2821	2-24-2015	...	...	...
2822-2	12-11-2017	...	...	...
2823-1	12-18-2017	...	...	...
2824	3-23-2015	...	...	...
2825	3-6-2015	...	...	...
2826-1	8-14-2018	...	...	...
2827-2	6-29-2018	...	...	...
2830	6-1-2015	...	...	...
2831-1	9-30-2018	...	...	...
2832	7-21-2015	...	...	...
2833	7-15-2015	...	...	...
2834	7-15-2015	...	...	...
2835	9-15-2015	...	...	...
2836-4	1-6-2022	...	...	...
2837	9-15-2015	...	...	...
2838	9-15-2015	...	...	...
2839-2	5-4-2022	...	...	...
2840-1	9-30-2018	...	...	...
2841	2-17-2016	...	...	...
2843-3	6-27-2023	...	...	...
2844	12-9-2015	...	...	...
2847-1	12-12-2019	...	...	...
2848	1-20-2016	...	...	...
2849	1-20-2016	...	...	...
2851	2-9-2016	...	...	...
2853	3-30-2015	...	...	...
2857	5-2-2016	...	...	...
2859	6-17-2016	...	...	...
2860	9-1-2016	...	...	...
2861	9-1-2016	...	...	...
2864-3	8-8-2022	...	...	...
2865	9-30-2016	...	...	...
2866	9-30-2016	...	...	...
2867-3	12-7-2020	...	...	...
2868-1	3-20-2018	...	...	3-30-2025
2869-1	12-2-2024	...	...	2869
2870-2	1-2-2024	...	...	...
2871-1	3-21-2017	...	...	...
2872	11-30-2016	...	...	...
2874	11-30-2016	...	...	...
2875	11-30-2016	...	...	...
2876-1	3-21-2017	...	...	...
2877	12-12-2016	...	...	...
2878	12-22-2016	...	...	...
2879	1-10-2017	...	...	...
2880	3-21-2017	...	...	...
2881	3-8-2017	...	...	...
2882-1	7-14-2018	...	...	...
2883	4-12-2017	...	1-1-2026	...
2884	4-4-2017	...	...	...
2886	8-7-2017	...	...	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
2887-2	4-16-2024	...	...	...
2888	8-24-2017	...	...	...
2889	7-6-2017	...	...	...
2890-4	5-12-2024	...	...	...
2892	10-13-2017	...	...	...
2893	10-16-2017	...	...	...
2894	10-16-2017	...	...	...
2895	10-16-2017	...	...	...
2896	8-9-2017	...	...	...
2897-1	12-18-2018	...	...	...
2898-1	6-19-2019	...	...	...
2899-1	6-19-2019	...	...	...
2900-1	6-19-2019	...	...	...
2901-1	1-8-2024	...	...	...
2902	12-12-2017	...	...	...
2903-1	12-7-2020	...	...	...
2904	12-18-2017	...	1-1-2026	...
2905	12-11-2017	...	...	...
2906	12-21-2017	...	...	...
2907	12-11-2017	...	...	...
2909-1	7-2-2019	...	...	...
2910	3-5-2018	...	...	...
2911-1	2-7-2023	...	...	...
2912	3-5-2018	...	...	...
2914	3-5-2018	...	...	...
2916	4-6-2018	...	...	...
2917	6-19-2019	...	...	...
2918	1-18-2018	...	...	...
2919-1	8-5-2022	...	...	...
2920	1-18-2018	...	...	...
2921	5-7-2018	...	...	...
2924	9-30-2018	...	...	...
2926	9-19-2018	...	...	...
2927	8-1-2018	...	...	...
2928	9-19-2018	...	...	...
2929	8-1-2018	...	...	...
2930	8-24-2018	...	...	...
2931	8-24-2018	...	...	...
2932	9-17-2018	...	...	...
2933	10-2-2018	...	...	...
2934	10-2-2018	...	...	...
2936	9-30-2018	...	...	...
2937	12-7-2018	...	...	...
2938-2	4-16-2024	...	...	...
2939	12-17-2018	...	...	...
2941	12-17-2018	...	...	...
2942	12-18-2018	...	...	...
2943	12-30-2018	...	...	...
2946-1	6-8-2020	...	...	...
2947	1-7-2019	...	...	...
2949-1	9-14-2020	...	...	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
2951	3-13-2019	...	...	...
2953	5-16-2019	...	...	...
2956	3-13-2019	...	...	...
2957	4-12-2019	...	...	...
2958	7-2-2019	...	...	...
2959-1	6-24-2021	...	...	3-30-2025
2960	6-19-2019	...	...	...
2961	6-19-2019	...	...	...
2963	7-30-2019	...	...	...
2964	7-2-2019	...	...	...
2965	7-24-2019	...	...	...
2967	8-28-2019	...	...	...
2968	8-28-2019	...	...	...
2969-2	9-3-2020	...	...	...
2970	10-15-2018	...	...	...
2971-1	9-3-2020	...	...	...
2972	10-6-2019	...	...	...
2973	11-21-2019	...	...	...
2974	11-1-2019	...	...	...
2975	11-1-2019	...	...	...
2976	10-11-2021	...	...	...
2978	7-16-2020	...	...	...
2979	12-4-2019	...	...	...
2981	11-1-2019	...	...	...
2982-2	1-8-2024	2025 ed.	...	...
2983	12-2-2019	...	...	...
2984-1	2-8-2022	...	...	...
2985	12-12-2019	...	...	...
2986-1	7-24-2020	...	...	...
2987	1-21-2020	...	...	...
2988	1-21-2020	...	...	...
2989	1-21-2020	...	...	...
2990	3-13-2020	...	...	...
2991	3-13-2020	...	...	...
2993	3-13-2020	...	...	...
2995	4-2-2020	...	...	...
2996-1	7-15-2020	...	...	...
2998-1	9-15-2020	...	...	...
3000	6-4-2020	...	...	...
3001-1	5-12-2024	...	...	...
3002	7-9-2020	...	...	...
3003	7-15-2020	...	...	...
3004	7-15-2020	...	...	...
3006	9-3-2020	...	...	...
3007	9-8-2020	...	...	...
3008	9-15-2020	...	...	...
3010	10-6-2020	...	...	...
3012	12-9-2020	...	...	...
3014	12-10-2020	...	...	...
3016	1-28-2021	...	...	...
3017	2-23-2021	...	...	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
3018	3-16-2021	...	...	...
3020	5-24-2021	...	...	...
3021	4-12-2021	...	...	12-28-2024
3022-1	1-8-2024	...	...	...
3023	6-24-2021	...	...	...
3024	7-22-2021	...	...	...
3025	6-24-2021	...	...	...
3026	7-15-2021	...	...	...
3027	8-9-2021	...	...	...
3028	7-15-2021	...	...	...
3029	6-24-2021	...	...	...
3030	8-19-2021	...	...	...
3031	8-20-2021	...	...	...
3033	11-27-2021	...	...	...
3034	12-15-2021	...	...	...
3035	1-3-2022	...	...	...
3036	1-6-2022	...	...	...
3037-1	6-15-2024	...	...	...
3038	1-10-2022	...	...	...
3039	3-3-2022	...	...	...
3040	3-17-2022	...	...	...
3041	4-1-2022	...	...	...
3042	4-1-2022	...	...	...
3043	4-1-2022	...	...	...
3044	4-6-2022	...	...	12-28-2024
3045	4-6-2022	...	...	...
3046	4-26-2022	...	...	...
3047	6-4-2022	...	...	...
3048	5-4-2022	...	...	...
3049-1	10-4-2023	...	...	...
3050	7-12-2022	...	...	...
3051	8-22-2022	...	...	...
3052	8-29-2022	...	...	...
3053	8-30-2022	...	1-1-2026	...
3054	9-6-2022	...	1-1-2026	...
3055	8-5-2022	...	...	...
3056	9-6-2022	...	...	...
3057	9-16-2022	...	...	...
3058	9-6-2022	...	...	...
3059	9-6-2022	...	...	...
3060	9-2-2022	...	...	...
3061	10-17-2022	...	...	...
3062	11-29-2022	...	...	...
3063-1	1-8-2024	...	...	...
3064	12-21-2022	...	...	...
3065	1-2-2023	...	...	...
3066	12-7-2022	...	...	...
3067	12-12-2022	...	...	...
3068-1	9-25-2024	...	...	...
3069	1-23-2023	...	...	...
3070	2-7-2023	...	1-1-2026	...

Case	Approval Date	Errata	Impending Annulment Date	Annulled Date/ Supersedes
3071	4-23-2023	...	...	...
3072	4-27-2023	...	...	...
3073	4-23-2023	...	...	...
3074	6-1-2023	...	...	...
3075	12-8-2022	...	...	...
3076	6-27-2023	...	...	...
3077	8-7-2023	...	...	...
3078-1	12-10-2024	...	...	3078
3079	9-18-2023	...	1-1-2026	...
3080	10-9-2023	...	...	...
3081	12-18-2023	...	...	...
3082	12-18-2023	...	...	...
3083	1-8-2024	...	...	...
3084	1-8-2024	...	...	...
3085	1-23-2024	...	...	...
3086	1-8-2024	...	...	...
3087	3-28-2024	...	...	...
3088	3-28-2024	...	...	...
3089	7-14-2024	...	...	...
3090	8-28-2024	...	...	...
3091	9-19-2024	...	...	...
3092	9-19-2024	...	...	...
3093	9-19-2024	...	...	...
3094	11-23-2024	...	...	...
3095	12-2-2024	...	...	...
3096	12-4-2024	...	...	...
3097	12-9-2024	...	...	...
3098	12-6-2024	...	...	...
3099	12-4-2024	...	...	...
3100	12-10-2024	...	...	...
3101	12-4-2024	...	...	...
3102	12-4-2024	...	...	...

SUBJECT INDEX

(25)

Subject **Case**

Section I
Power Boilers (Cont'd)

Section II
Materials Part A — Ferrous

Section II
Materials Part B — Nonferrous

Section II
Welding Specifications — Part C

Section II
Material Properties — Part D

Section IV
Heating Boilers

Subject **Case**

Section IV
Heating Boilers (Cont'd)

Subject	Case

Section IV
Heating Boilers (Cont'd)

(25) # INDEX OF MATERIAL SPECIFICATIONS REFERRED TO IN CASES

CHARTS FOR VESSELS UNDER EXTERNAL PRESSURE

INTENTIONALLY LEFT BLANK

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 T351[1]
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 T351[1] 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 in. < t ≤ 3.5 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.

INTENTIONALLY LEFT BLANK

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)

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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)]	$1^1/_4$Cr–$^1/_2$Mo-Si, ksi [Note (3)]	$2^1/_4$Cr–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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $1\frac{1}{2}$ in. inclusive. A preheat of 200°F is required for nominal thicknesses greater than $1\frac{1}{2}$ 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 $1\frac{1}{2}$ 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	
$t \le \frac{3}{4}$ in.	25.7
Class 2	
$t \le 2$ in.	20.6
2 in. $< t \le 4$ in.	18.6
Class 3	
$t \le 2$ in.	24.3
2 in. $< t \le 4$ in.	21.4
A859	
Class 1	
$t \le 4$ in.	18.6
Class 2	
$t \le 4$ 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	
$t \leq 3/4$ 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.

INTENTIONALLY LEFT BLANK

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 used[1] 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).

INTENTIONALLY LEFT BLANK

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 $3\frac{1}{2}$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 ft^3 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $^1/_2$ in.

(2) For corner or lap welded joints, the thinner of the two parts joined shall not exceed $^1/_2$ 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).

INTENTIONALLY LEFT BLANK

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 66⅔% 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 66⅔% 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)			
		$\frac{1}{2}$ in. or less	Over $\frac{1}{2}$ 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 construction 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 $^1/_{10}$ of the room temperature specified minimum tensile strength.)

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

INTENTIONALLY LEFT BLANK

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 4*D* 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 $^2/_3$, 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 fspecifications.

(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 $120\text{ksi-}\sqrt{\text{in.}}$ 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

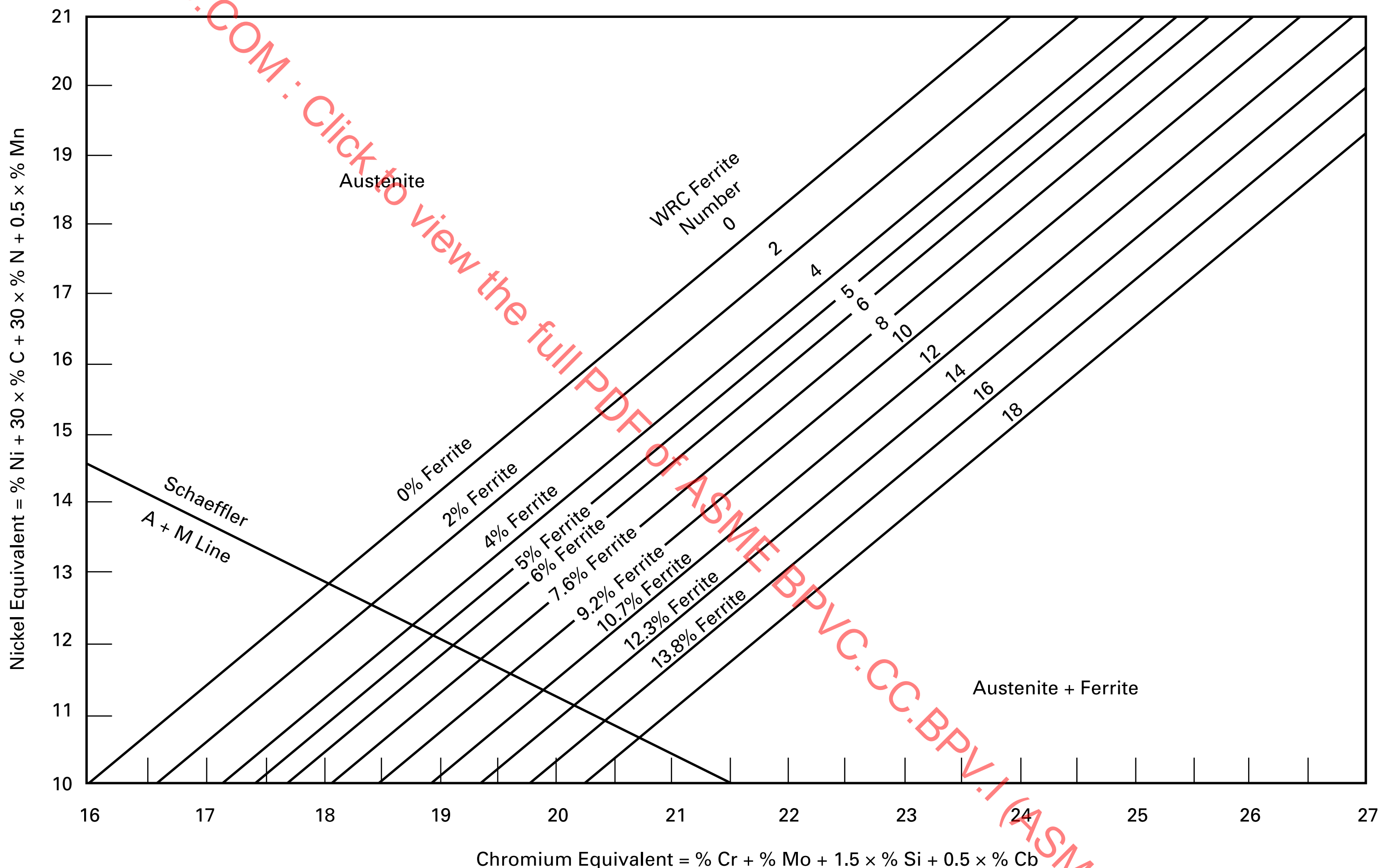
Element	Weight, %
Carbon, max.	0.030
Manganese	[Note (1)]
Phosphorus, max.	0.025
Sulfur, max.	0.015
Silicon	[Note (1)]
Nickel	[Note (1)]
Chromium	[Note (1)]
Nitrogen	0.13–0.16
Other Elements	[Note (1)]

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



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%

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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

INTENTIONALLY LEFT BLANK

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

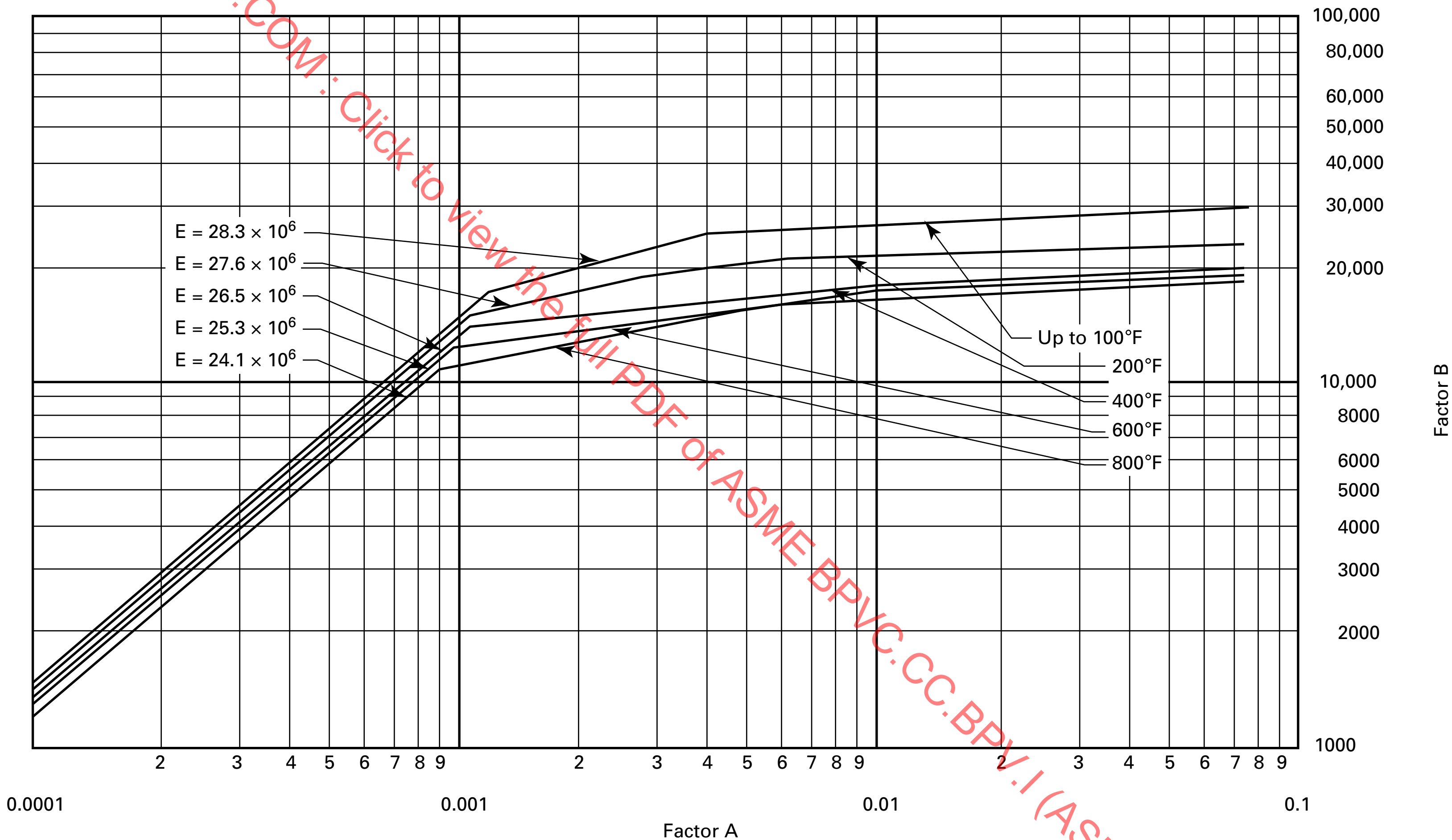
For Metal Temperature Not Exceeding, °F	Forgings, Bar, Plate, Sheet, Strip, Seamless Pipe and Tube, Fittings	Welded Pipe and Tube, Welded Fittings [Note (1)]
100	28.8	24.5
200	28.4	24.1
300	26.9	22.9
400	25.9	22.0
500	25.3	21.5
600	25.0	21.3
650	24.8	21.1
700	24.6	20.9
750	24.3	20.7

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 × 10^6 psi		Temp. 200°F, E = 27.6 × 10^6 psi		Temp. 400°F, E = 26.5 × 10^6 psi		Temp. 600°F, E = 25.3 × 10^6 psi		Temp. 800°F, E = 24.1 × 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



INTENTIONALLY LEFT BLANK

Case 2150
Large-End Cone-to-Cylinder Junction for 30 < α ≤ 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.

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

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

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

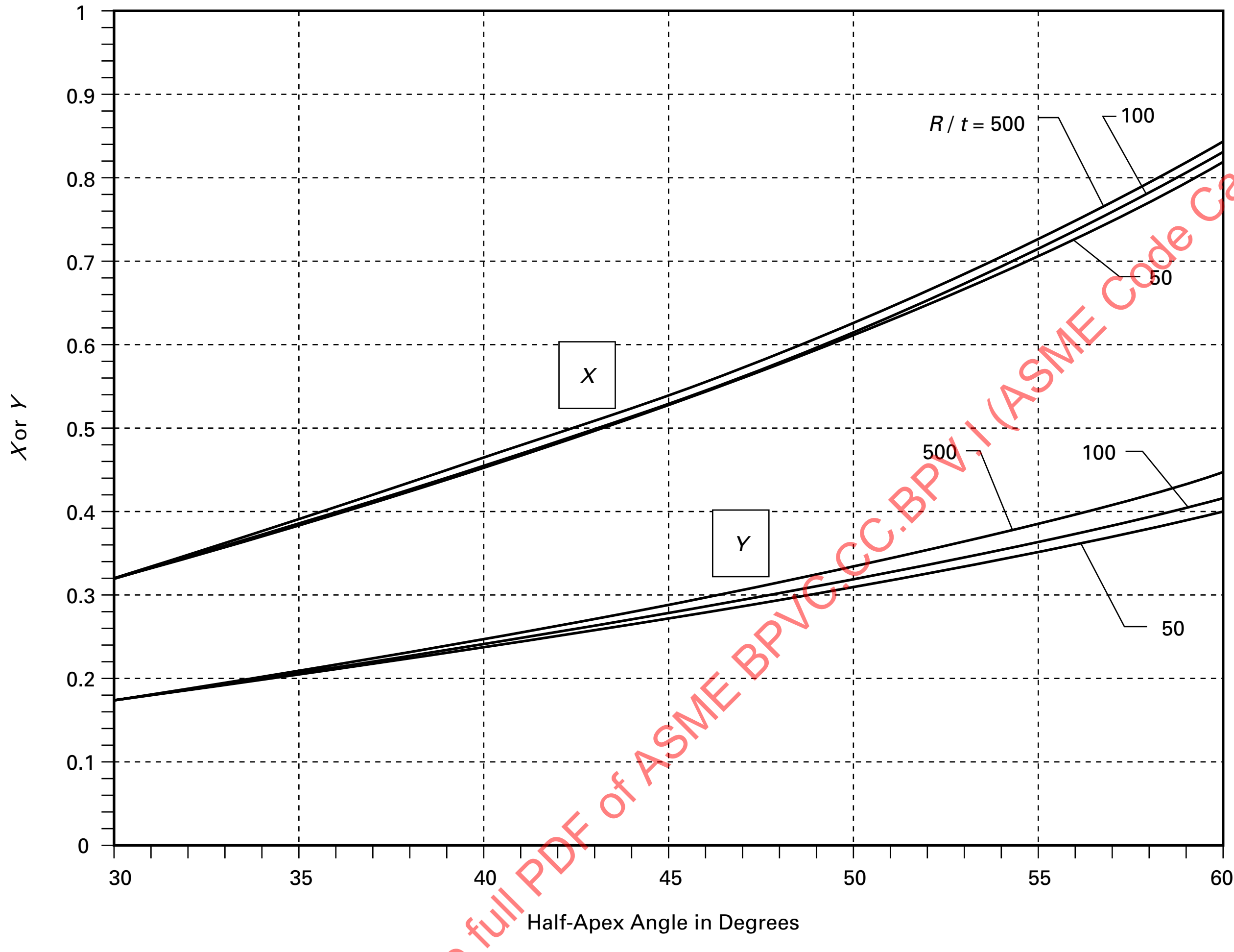


Figure 2
***X* and *Y* For Cone Thickness = *t*/cos α**

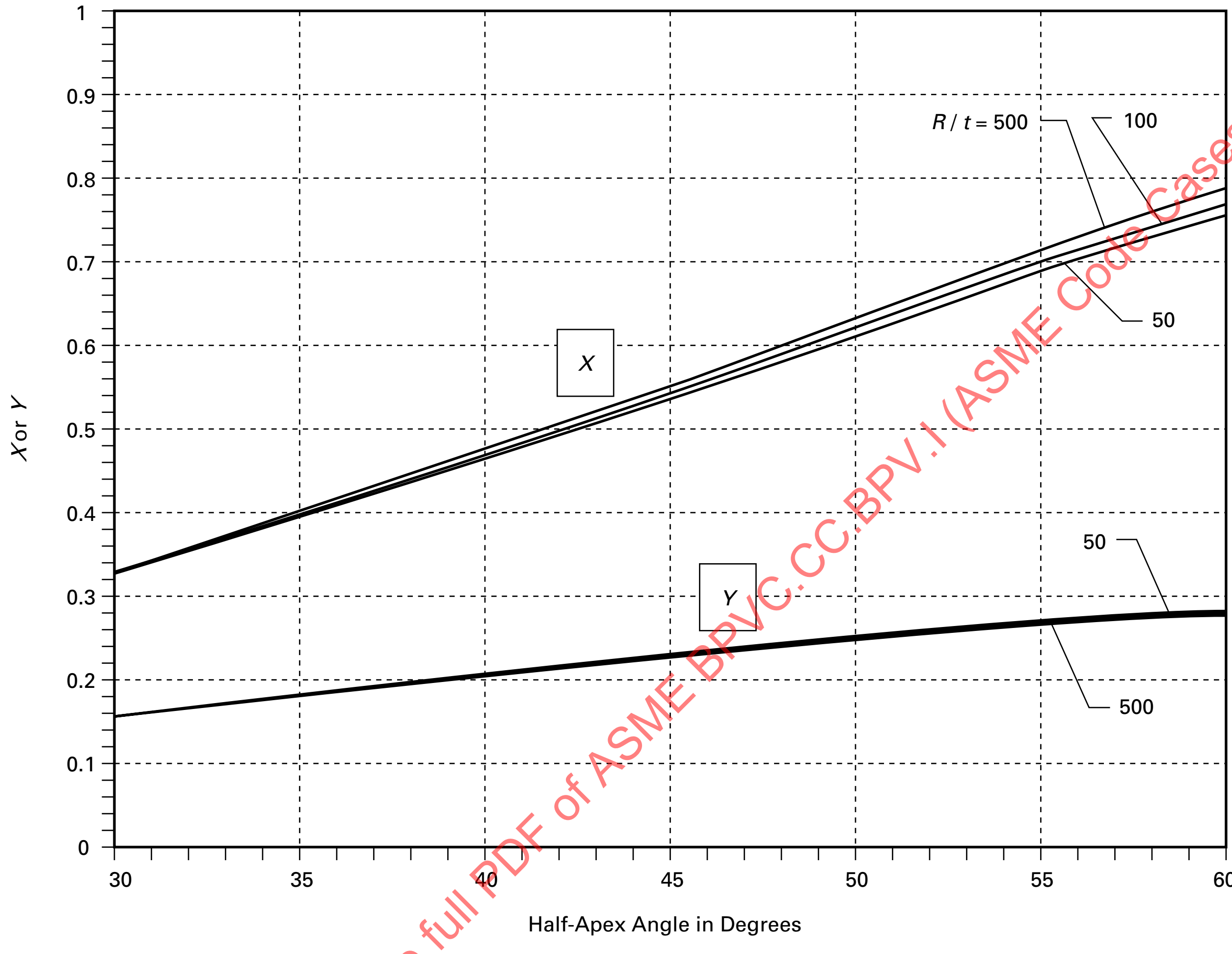


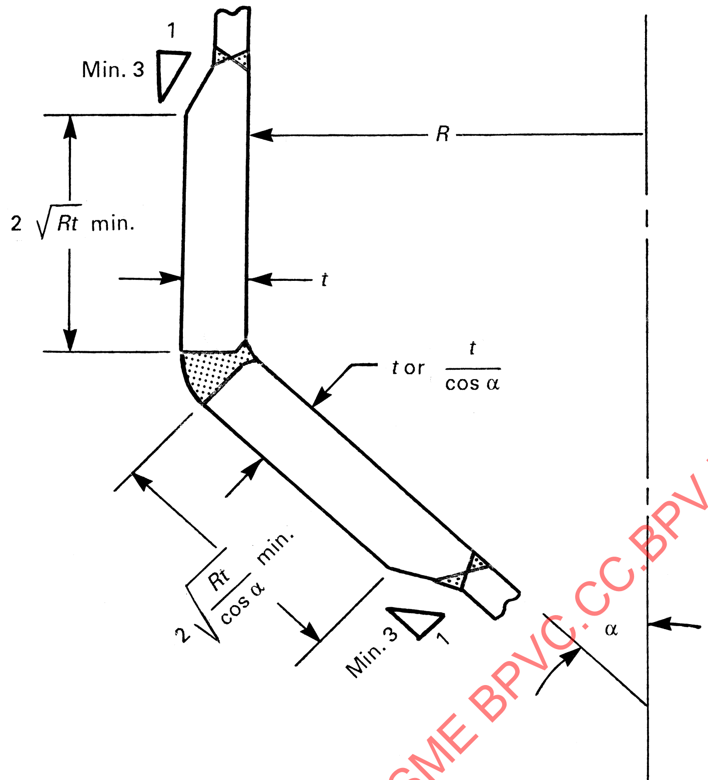
Table 1
Tabular Values for Figure 1

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


1
Min. 3
R
$2\sqrt{Rt}$ min.
t
t or $\frac{t}{\cos\alpha}$
$2\sqrt{\frac{Rt}{\cos\alpha}}$ min.
Min. 3
1
α

Case 2151-3
3 Chromium-1 Molybdenum-¼ 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, *S*, 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-¹⁄₄V-Ti-B, which is similar to 3Cr-1Mo-¹⁄₄V-Cb-Ca, except that the creep strength of 3Cr-1Mo-¹⁄₄V-Cb-Ca alloy is slightly higher than that of 3Cr-1Mo-¹⁄₄V-Ti-B.

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

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Value, *S*, 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-¹⁄₄V-Ti-B, which is similar to 3Cr-1Mo-¹⁄₄V-Cb-Ca, except that the creep strength of 3Cr-1Mo-¹⁄₄V-Cb-Ca alloy is slightly higher than that of 3Cr-1Mo-¹⁄₄V-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.

INTENTIONALLY LEFT BLANK

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 be1,350°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, reaustenized 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 (1 040°C to 1 080°C), followed by air or accelerated cooling[1] 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.

[1] To 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 reaustenitized 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, reaustenitized, 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 ≥1,000°F (≥550°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.

INTENTIONALLY LEFT BLANK

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 (1 040°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, *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 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	*83.0, 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 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 requirements. 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.

INTENTIONALLY LEFT BLANK

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 (1 040°C to 1 080°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 ½ 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 reaustenitized 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 1 040°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 reaustenitizing 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 reaustenitized 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 ½ in. (13 mm) shall be reaustenitized 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 reaustenitized 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, reaustenitized, 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 4*D*, 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, °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, °F	Design Stress Intensity Value, Max., ksi H1150 Condition
100	45.0
200	45.0
300	45.0

INTENTIONALLY LEFT BLANK

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 66⅔%, 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.

INTENTIONALLY LEFT BLANK

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 $66^2/_3$%, 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.

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	Other Elements 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) [Note (1)]	ksi (A03570) [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

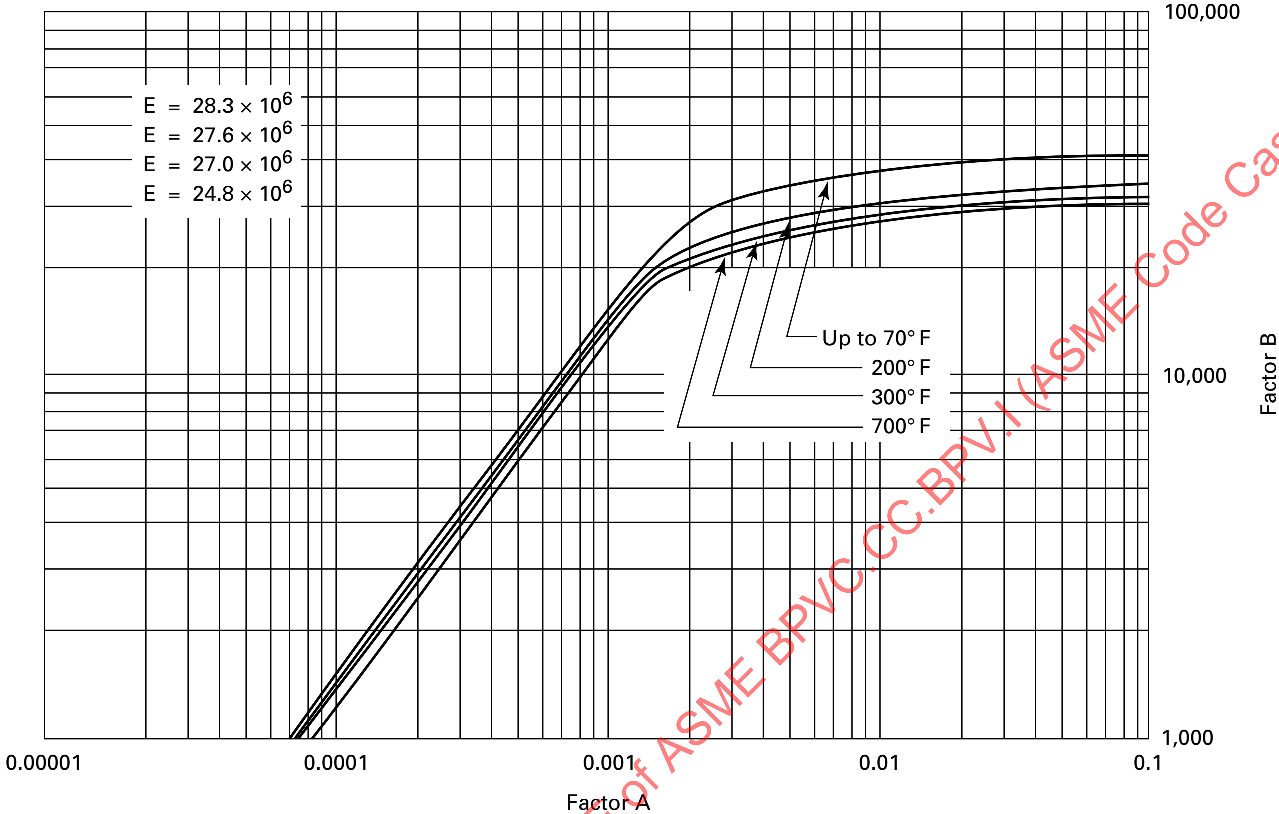


Table 4
Chart for Determining Shell Thickness of Cylindrical and Spherical Shells Under External Pressure When Constructed of High Alloy UNS S32760 And UNS J93380

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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 ft^3. 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 valves[1] 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:

$$C_v = 5.69 K_d K_s A \sqrt{\frac{P_r}{\delta}}$$

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/ft^3)

(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 nameplate 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.

$$t = \frac{PLM}{2SE - 0.2P} \quad (1)$$

$$t = \frac{3PLKE_{RT}}{4S_aE_T} \quad (2)$$

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 ≤ 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

INTENTIONALLY LEFT BLANK

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 4*D* 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 $1.2\sqrt{D_o t}$), 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
= $\pi(D_o - t)t$, 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

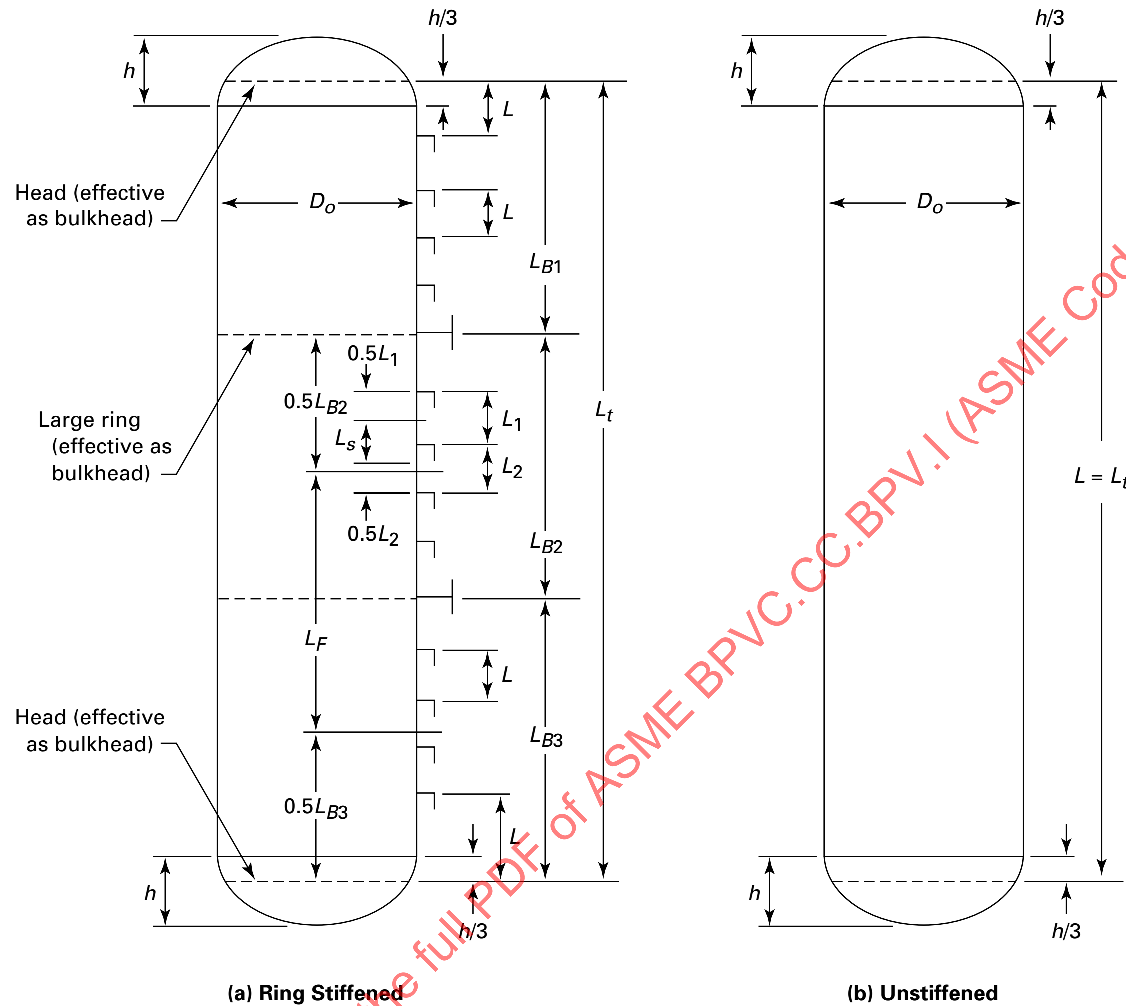
F_{ha} = allowable hoop compressive membrane stress of a cylinder or formed head under external pressure alone, ksi

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

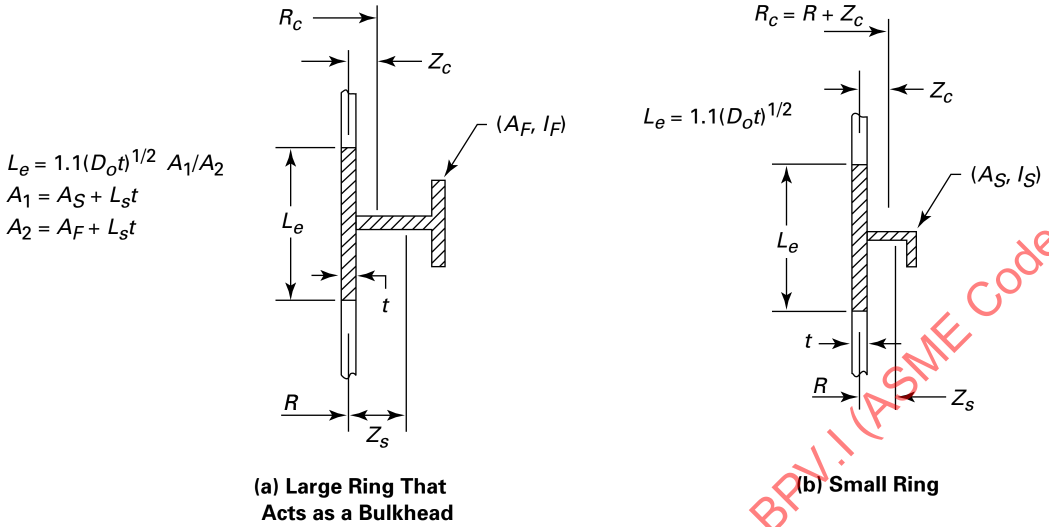


Figure 1.4.3
Geometry of Conical Sections

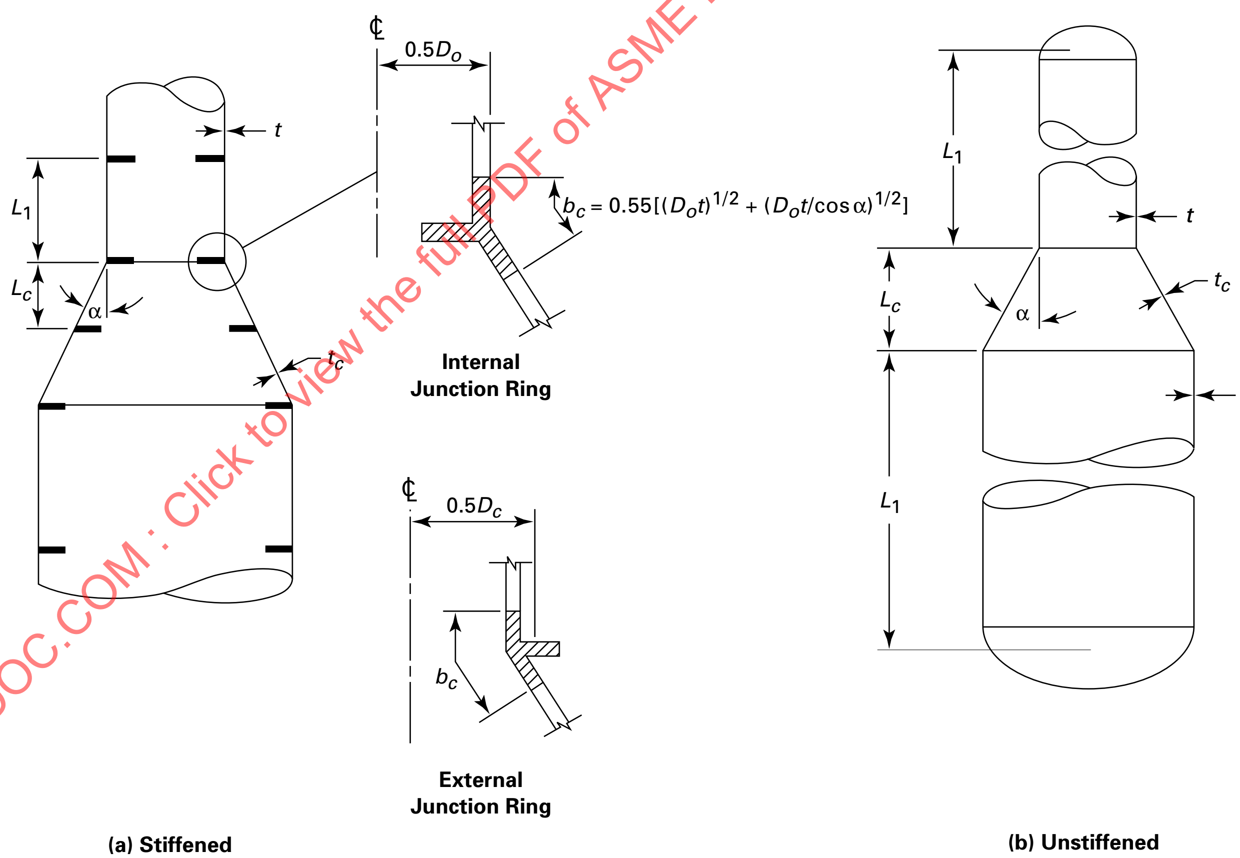
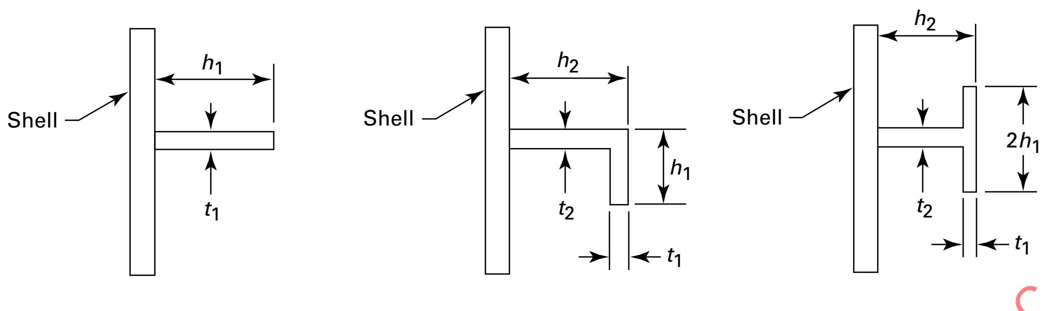


Figure 1.4.4
Stiffener Geometry for Eqs. 6.4(a)(6-6) and 6.4(b)(6-7)



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 additional 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.

$$r = \frac{\left(D_o^2 + D_i^2\right)^{1/2}}{4}$$

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 λ_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:

$$F_{xa} = \frac{F_{xe}}{FS}\frac{E_t}{E} \quad F_{ba} = F_{xa} \quad F_{ha} = \frac{F_{he}}{FS}\frac{E_t}{E} \quad F_{va} = \frac{F_{ve}}{FS}\frac{E_t}{E}$$

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.

$$\begin{aligned} FS &= 2.0 && \text{if } F_{ic} \le 0.55F_y \\ FS &= 2.407 - 0.741F_{ic}/F_y && \text{if } 0.55F_y < F_{ic} < F_y \\ FS &= 1.667 && \text{if } F_{ic} \ge F_y \end{aligned}$$

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:

$$\beta = 0.207 \quad \text{for } \frac{D_o}{t} \geq 1{,}247$$

$$\beta = \frac{338}{389 + \frac{D_o}{t}} \quad \text{for } \frac{D_o}{t} < 1{,}247$$

(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.

$$P_a = 2F_{ha}\frac{t}{D_o}$$

$$F_{ha} = \frac{F_y}{FS} \quad \text{for} \frac{F_{he}}{F_y} \geq 2.439 \qquad (3\text{-}1a)$$

$$F_{ha} = \frac{0.7F_y}{FS}\left(\frac{F_{he}}{F_y}\right)^{0.4} \quad \text{for} \quad 0.552 < \frac{F_{he}}{F_y} < 2.439 \qquad (3\text{-}1b)$$

$$F_{ha} = \frac{F_{he}}{FS} \quad \text{for} \quad \frac{F_{he}}{F_y} \leq 0.552 \qquad (3\text{-}1c)$$

where

$$F_{he} = 1.6C_hE\frac{t}{D_o} \qquad (3\text{-}2)$$

$$C_h = 0.55\frac{t}{D_o} \quad \text{for} \quad M_x \geq 2\left(\frac{D_o}{t}\right)^{0.94} \qquad (3\text{-}2a)$$

$$C_h = 1.12M_x^{-1.058} \quad \text{for} \quad 13 < M_x < 2\left(\frac{D_o}{t}\right)^{0.94} \qquad (3\text{-}2b)$$

$$C_h = \frac{0.92}{M_x - 0.579} \quad \text{for} \quad 1.5 < M_x \leq 13 \qquad (3\text{-}2c)$$

$$C_h = 1.0 \quad \text{for} \quad M_x \leq 1.5 \qquad (3\text{-}2d)$$

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 $\lambda_c \le 0.15$).

F_{xa} is the smaller of the values given by eqs. (3-3a) through (3-3c) and (3-4).

$$F_{xa} = \frac{F_y}{FS} \quad \text{for} \quad \frac{D_o}{t} \le 135 \tag{3-3a}$$

$$F_{xa} = \frac{466F_y}{\left(331 + \frac{D_o}{t}\right)FS} \quad \text{for} \quad 135 < \frac{D_o}{t} < 600 \tag{3-3b}$$

$$F_{xa} = \frac{0.5F_y}{FS} \quad \text{for} \quad \frac{D_o}{t} \ge 600 \tag{3-3c}$$

or

$$F_{xa} = \frac{F_{xe}}{FS} \tag{3-4}$$

where

$$F_{xe} = \frac{C_x E t}{D_o} \tag{3-5}$$

$$C_x = \frac{409\bar{c}}{389 + \frac{D_o}{t}} \quad \text{not to exceed 0.9 for} \quad \frac{D_o}{t} < 1247$$

$$C_x = 0.25\bar{c} \quad \text{for} \quad \frac{D_o}{t} \ge 1247$$

$$\bar{c} = 2.64 \quad \text{for} \quad M_x \le 1.5$$

$$\bar{c} = \frac{3.13}{M_x^{0.42}} \quad \text{for} \quad 1.5 < M_x < 15$$

$$\bar{c} = 1.0 \quad \text{for} \quad M_x \ge 15$$

$$M_x = \frac{L}{(R_o t)^{1/2}} \tag{3-6}$$

3.2.2 Column Buckling ($\lambda_c > 0.15$ and $KL_u/r < 200$).

$$F_{ca} = F_{xa}[1 - 0.74(\lambda_c - 0.15)]^{0.3} \tag{3-7a}$$

for $0.15 < \lambda_c < 1.2$

$$F_{ca} = \frac{0.88F_{xa}}{\lambda_c^2} \quad \text{for} \quad \lambda_c \ge 1.2 \tag{3-7b}$$

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}.

$$F_{ba} = F_{xa} \text{ (see 3.2.1)} \quad \text{for} \quad \frac{D_o}{t} \ge 135 \tag{3-8a}$$

$$F_{ba} = \frac{466F_y}{FS\left(331 + \frac{D_o}{t}\right)} \quad \text{for} \quad 100 \le \frac{D_o}{t} < 135 \tag{3-8b}$$

$$F_{ba} = \frac{1.081F_y}{FS} \quad \text{for} \quad \frac{D_o}{t} < 100 \quad \text{and} \quad \gamma \ge 0.11 \tag{3-8c}$$

$$F_{ba} = \frac{(1.4 - 2.9\gamma)F_y}{FS} \quad \text{for} \quad \frac{D_o}{t} < 100 \text{ and } \gamma < 0.11 \tag{3-8d}$$

where

$$\gamma = \frac{F_y D_o}{E\,t} \tag{3-8e}$$

3.4 SHEAR

Allowable in-plane shear stress for a cylindrical shell is given by F_{va}.

$$F_{va} = \frac{\eta_v F_{ve}}{FS} \tag{3-9}$$

where

$$F_{ve} = \alpha_v C_v E \frac{t}{D_o} \tag{3-10}$$

$$C_v = 4.454 \quad \text{for} \quad M_x \le 1.5 \tag{3-11a}$$

$$C_v = \left(\frac{9.64}{M_x^2}\right)\left(1 + 0.0239M_x^3\right)^{1/2} \quad \text{for } 1.5 < M_x < 26 \tag{3-11b}$$

$$C_v = \frac{1.492}{M_x^{1/2}} \quad \text{for} \quad 26 \le M_x < 4.347\frac{D_o}{t} \tag{3-11c}$$

$$C_v = 0.716\left(\frac{t}{D_o}\right)^{1/2} \quad \text{for} \quad M_x \ge 4.347\frac{D_o}{t} \tag{3-11d}$$

$$\alpha_v = 0.8 \quad \text{for} \frac{D_o}{t} \le 500 \tag{3-11e}$$

$$\alpha_v = 1.389 - 0.218\log_{10}\left(\frac{D_o}{t}\right) \quad \text{for} \frac{D_o}{t} > 500 \tag{3-11f}$$

$$\eta_v = 1.0 \quad \text{for} \frac{F_{ve}}{F_y} \le 0.48 \tag{3-11g}$$

$$\eta_v = 0.43\frac{F_y}{F_{ve}} + 0.1 \quad \text{for} \quad 0.48 < \frac{F_{ve}}{F_y} < 1.7 \tag{3-11h}$$

$$\eta_v = 0.6\frac{F_y}{F_{ve}} \quad \text{for} \quad \frac{F_{ve}}{F_y} \ge 1.7 \tag{3-11i}$$

4 ALLOWABLE COMPRESSIVE STRESSES FOR CONES

Unstiffened conical transitions or cone sections between rings of stiffened cones with an angle α ≤ 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:

$$I_c \ge \frac{D^2}{16E}\left\{tL_1F_{he} + \frac{t_cL_cF_{hec}}{\cos^2\alpha}\right\} \tag{4-1}$$

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.

$$f_b' = \frac{0.6t\sqrt{D(t + t_c)}}{t_e^2}(f_x + f_b)\tan\alpha \tag{4-2}$$

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:

$$f'_h = 0.45\sqrt{D/t}(f_x + f_b)\tan\alpha \tag{4-3}$$

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:

$$A_c \geq \frac{tD}{F_y}(f_x + f_b)\tan\alpha \tag{4-4}$$

$$I_c \geq \frac{tD(D_c)^2}{8E}(f_x + f_b)\tan\alpha \tag{4-5}$$

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:

$$b_e = 0.55\left(\sqrt{Dt} + \sqrt{Dt_c/\cos\alpha}\right) \tag{4-6}$$

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}.

$$f_x \leq F_{xha}$$

$$F_{xha} = \left(\frac{1}{F_{xa}{}^2} - \frac{C_1}{C_2 F_{xa} F_{ha}} + \frac{1}{C_2{}^2 F_{ha}{}^2} \right)^{-0.5} \quad (5\text{-}1)$$

where

$$C_1 = \frac{(F_{xa}FS + F_{ha}FS)}{F_y} - 1.0 \quad (5\text{-}1a)$$

and

$$C_2 = \frac{f_x}{f_h} \quad (5\text{-}1b)$$

$$f_x = f_a + f_q = \frac{Q}{A} + \frac{Q_p}{A} \quad \text{and} \quad f_h = \frac{PD_o}{2t}$$

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.

$$F_{hxa} = \frac{F_{xha}}{C_2} \quad (5\text{-}2)$$

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.)

$$f_a \leq F_{aha} \quad \text{where} \quad F_{aha} = F_{cha}\left(1 - \frac{f_q}{F_y}\right) \quad (5\text{-}3)$$

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:

$$F_{cha} = F_{xha} \quad \text{for} \quad \lambda_c \leq 0.15 \quad (5\text{-}3a)$$

$$F_{cha} = F_{xha}[1 - 0.74(\lambda - 0.15)]^{0.3} \text{ for } 0.15 < \lambda_c < 1.2 \quad (5\text{-}3b)$$

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}.

$$F_b \leq F_{bha}$$
$$F_{bha} = C_3 C_4 F_{ba} \quad (5\text{-}4)$$

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).

$$C_4 = \frac{f_b}{f_h}\frac{F_{ha}}{F_{ba}} \quad (5\text{-}4a)$$

$$C_3{}^2\left(C_4{}^2 + 0.6C_4\right) + C_3{}^{2n} - 1 = 0 \quad (5\text{-}5)$$

$$f_b = \frac{Mc}{I} \quad \text{and} \quad f_h = \frac{PD_o}{2t} \quad \text{and} \quad n = 5 - 4\frac{F_{ha} \cdot FS}{F_y}$$

Solve for C_3 from eq. (5-5) by iteration. F_{ha} is given by eq. 3.1(3-1a).

$$F_{hba} = F_{bha}\frac{f_h}{f_b} \quad (5\text{-}6)$$

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}.

$$F_{vha} = \left[\left(\frac{F_{va}{}^2}{2C_5F_{ha}}\right)^2 + F_{va}{}^2\right]^{1/2} - \frac{F_{va}{}^2}{2C_5F_{ha}} \quad (5\text{-}7)$$

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).

$$F_{hva} = \frac{F_{vha}}{C_5} \tag{5-8}$$

5.4 FOR COMBINATION OF UNIFORM AXIAL COMPRESSION, AXIAL COMPRESSION DUE TO BENDING MOMENT, *M*, AND SHEAR, IN THE PRESENCE OF HOOP COMPRESSION ($f_h \neq 0$)

$$\text{Let} \quad K_s = 1 - \left(\frac{f_v}{F_{va}}\right)^2 \tag{5-9}$$

5.4.1 For $\lambda_c \leq 0.15$

$$\left(\frac{f_a}{K_s F_{xha}}\right)^{1.7} + \frac{f_b}{K_s F_{bha}} \leq 1.0 \tag{5-10}$$

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 $0.15 < \lambda_c < 1.2$

$$\frac{f_a}{K_s F_{aha}} + \frac{8}{9}\frac{\Delta f_b}{K_s F_{bha}} \leq 1.0 \tag{5-11}$$

$$\text{for } \frac{f_a}{K_s F_{aha}} \geq 0.2 \tag{5-12}$$

$$\frac{f_a}{2K_s F_{aha}} + \frac{\Delta f_b}{K_s F_{bha}} \leq 1.0 \quad \text{for} \quad \frac{f_a}{K_s F_{aha}} < 0.2$$

where

$$\Delta = \frac{C_m}{1 - \frac{f_a FS}{F_e}} \tag{5-12a}$$

$$F_e = \frac{\pi^2 E}{(K L_u / r)^2} \tag{5-12b}$$

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 $\lambda_c \leq 0.15$

$$\left(\frac{f_a}{K_s F_{xa}}\right)^{1.7} + \frac{f_b}{K_s F_{ba}} \leq 1.0 \tag{5-13}$$

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 $0.15 < \lambda_c < 1.2$

$$\frac{f_a}{K_s F_{ca}} + \frac{8}{9}\frac{\Delta f_b}{K_s F_{ba}} \le 1.0 \quad \text{for} \frac{f_a}{K_s F_{ca}} \ge 0.2 \tag{5-14}$$

$$\frac{f_a}{2K_s F_{ca}} + \frac{\Delta f_b}{K_s F_{ba}} \le 1.0 \quad \text{for} \frac{f_a}{K_s F_{ca}} < 0.2 \tag{5-15}$$

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

$$I_s' \ge \frac{1.5 \quad F_{he} \quad L_s R_c^{\,2} t}{E(n^2 - 1)} \tag{6-1}$$

where

F_{he} = stress determined from eq. 3.1(3-2) with $M_x = M_s$

$n^2 = \dfrac{2D_o^{\,3/2}}{3L_B t^{1/2}}$

n = 2 for $n^2 \le 4$

= 10 for $n^2 > 100$

(b) Large rings that act as bulkheads

$$I_s' \ge I_F \tag{6-2}$$

$$I_F = \frac{F_{heF} L_F R_c^{\,2} t}{2E} \tag{6-2a}$$

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.

$$A_s \ge \left[\frac{0.334}{M_s^{\,0.6}} - 0.063\right] L_s t \quad \text{and} \quad A_s \ge 0.06 L_s t \tag{6-3}$$

$$\text{also} \quad I_s' \ge \frac{5.33 L_s t^3}{M_s^{\,1.8}} \tag{6-4}$$

6.3 SHEAR

$$I_s' \ge 0.184\, C_v M_s^{\,0.8} t^3 L_s \tag{6-5}$$

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

$$\frac{h_1}{t_1} \le 0.375\left(\frac{E}{F_y}\right)^{1/2} \tag{6-6}$$

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

$$\frac{h_2}{t_2} \le 1.0\left(\frac{E}{F_y}\right)^{1/2} \tag{6-7}$$

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.

$$e = 0.0165t(M_x + 3.25)^{1.069} \tag{7-1}$$

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.

e_x = 0.002R
L_x = $4\sqrt{Rt}$ but not greater than L for cylinders
= $4\sqrt{Rt/\cos\alpha}$ but not greater than $L_c/\cos\alpha$ for cones
= $25t$ across circumferential welds

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, $F_{xa(reduced)}$, 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).

$$F'_{xe} = \left[0.944 - 0.286\log\left(\frac{e}{e_x}0.0005\right)\right]E\frac{t}{R} \tag{7-2}$$

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:

$$F'_{xe} = 0.086E\frac{t}{R} \tag{7-3}$$

$$\text{Then} \quad F_{xa(\text{reduced})} = \frac{F_{xa}{*}FS_{xa} - F'_{xe}}{FS_{xa}} \tag{7-3a}$$

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

$$L_c = 2R\sin(\pi/2n) \tag{7-4}$$

$$n = c\left(\frac{\sqrt{R/t}}{L/R}\right)^d \quad \text{and} \quad 2 \le n \le 1.41(R/t)^{0.5} \tag{7-5}$$

where

c = $2.28(R/t)^{0.54} \le 2.80$
d = $0.38(R/t)^{0.44} \le 0.485$

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.

$$F_{ha} = \frac{F_y}{FS} \quad \text{for} \quad \frac{F_{he}}{F_y} \ge 6.25 \tag{8-1a}$$

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

$$F_{ha} = \frac{1.31F_y}{FS\left(1.15 + \frac{F_y}{F_{he}}\right)} \quad \text{for } 1.6 < \frac{F_{he}}{F_y} < 6.25 \tag{8-1b}$$

$$F_{ha} = \frac{0.18F_{he} + 0.45F_y}{FS} \quad \text{for } 0.55 < \frac{F_{he}}{F_y} \leq 1.6 \tag{8-1c}$$

$$F_{ha} = \frac{F_{he}}{FS} \quad \text{for } \frac{F_{he}}{F_y} \leq 0.55 \tag{8-1d}$$

$$F_{he} = 0.075E\frac{t}{R_o} \tag{8-2}$$

$$P_a = 2F_{ha}\frac{t}{R_o} \tag{8-3}$$

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_1 are compression stresses resulting from applied loads, are given by the following equations.

$$F_{1a} = \frac{0.6}{1 - 0.4k}F_{ha} \tag{8-4}$$

$$F_{2a} = kF_{1a} \tag{8-5}$$

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 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).

$$F_{he} = (C_o + C_p)E\frac{t}{R_o} \tag{8-6}$$

$$C_o = \frac{102.2}{195 + R_o / t} \quad \text{for } \frac{R_o}{t} < 622 \tag{8-6a}$$

$$C_o = 0.125 \quad \text{for } \frac{R_o}{t} \geq 622 \tag{8-6b}$$

$$C_p = \frac{1.06}{3.24 + \frac{1}{\overline{p}}}, \quad \overline{p} = \frac{\sigma^2}{E}\frac{R_o}{t} \tag{8-6c}$$

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_oD_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:

$$L_e = 3.72\sqrt{Rt} \tag{8-7}$$

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:

$$\text{Where} \quad \gamma_n = \left(\frac{d}{2\sqrt{Rt}}\right)$$

For $d \le 0.4\sqrt{Rt}$

$$A_r = 0 \tag{9-1}$$

For $d > 0.4\sqrt{Rt}$ and $\gamma_n \le \left(\frac{R/t}{291} + 0.22\right)^2$

$$A_r = 0.5dt_r \tag{9-2}$$

For $d > 0.4\sqrt{Rt}$ and $\gamma_n > \left(\frac{R/t}{291} + 0.22\right)^2$

$$A_r = 1.0dt_r \tag{9-3}$$

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.

INTENTIONALLY LEFT BLANK

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

INTENTIONALLY LEFT BLANK

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–$^1/_5$Mo	E, Class 55	55	85	24.3
1Cr–$^1/_5$Mo	F, Class 55	55	85	24.3
1Cr–$^1/_5$Mo	F, Class 65	65	105	30.0
$^1/_2$Cr–$^1/_2$Mo	G, Class 55	55	85	24.3
$^1/_2$Cr–$^1/_2$Mo	G, Class 65	65	105	30.0
$^1/_2$Cr–$^1/_2$Mo	H, Class 55	55	85	24.3
$^1/_2$Cr–$^1/_2$Mo	H, Class 65	65	105	30.0
1Cr–$^1/_5$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.

INTENTIONALLY LEFT BLANK

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:

≤1150°F (620°C)	y = 0.4
1200°F (650°C)	y = 0.5
≥1250°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 66⅔% 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 66⅔% 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 $^3/_{16}$ in.

(b) The flat plate pre-machined nominal thickness shall not be thicker than $1^1/_2$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $^{3}/_{8}$ 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.

INTENTIONALLY LEFT BLANK

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 (1 040°C to 1 080°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 reaustenitized and retempered, per (a). Normalizing and tempering are required for all cold swages, flares, and upsets regarless 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 reaustenitized 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, 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 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, reaustenized, 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., %
$^{5}/_{16}$ (8.0)	20.0
$^{9}/_{32}$ (7.2)	19.0
$^{1}/_{4}$ (6.4)	18.0
$^{7}/_{32}$ (5.6)	17.0
$^{3}/_{16}$ (4.8)	16.0
$^{5}/_{32}$ (4.0)	15.0
$^{1}/_{8}$ (3.2)	14.0
$^{3}/_{32}$ (2.4)	13.0

GENERAL NOTE: The above table gives the computed minimum elongation values for each $^{1}/_{32}$ 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 $^{1}/_{32}$ in. (0.8 mm) decrease in wall thickness below $^{5}/_{16}$ 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.

INTENTIONALLY LEFT BLANK

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 ¼ 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).

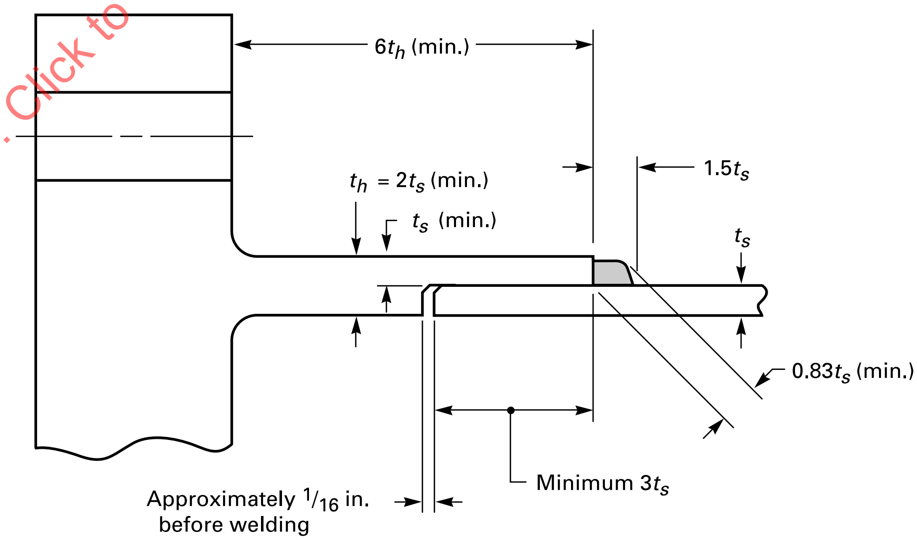
(g) The heat exchanger is not in lethal service (see UW-2).

(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



INTENTIONALLY LEFT BLANK

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 $^5/_8$ 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 $^7/_{16}$ 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.

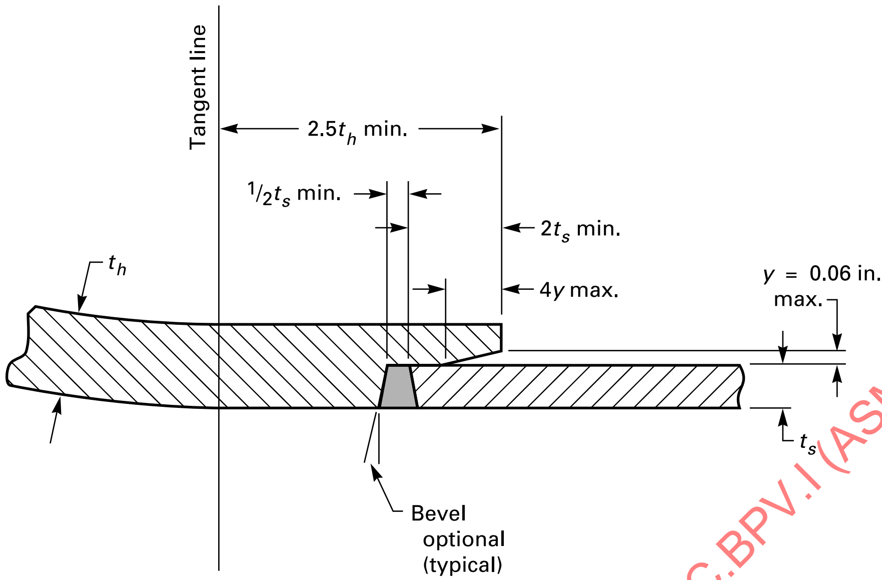
(l) The materials of construction shall be P-No. 1, Group 1 or 2.

(m) If this Case is used for vessels in chlorine services the requirements of the Chlorine Institute Pamphlet 17[1] 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


Tangent line
2.5t_h min.
$^1/_2t_s$ min.
2t_s min.
t_h
4y max.
y = 0.06 in. max.
t_s
Bevel optional (typical)

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 BAlSi-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 BAlSi-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.

INTENTIONALLY LEFT BLANK

Case 2351-1[1]
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.

[1] There 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, T, 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, T, 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 × 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 × 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), $^1/_2$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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

(Cont'd)

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	*16.3, 16.3*
1,050	*12.3, 12.3*
1,100	*9.2, 9.2*
1,150	*6.9, 6.9*
1,200	*4.1, 4.1*
1,250	*2.8, 2.8*
1,300	*2.0, 2.0*
1,350	*1.5, 1.5*
1,400	*1.2, 1.2*
1,450	*0.97, 0.97*
1,500	*0.80, 0.80*
1,550	*0.68, 0.68*
1,600	*0.58, 0.58*
1,650	*0.51, 0.51*
1,700	*0.44, 0.44* [Note (4)]
1,750	*0.37, 0.37* [Note (4)]
1,800	*0.32, 0.32* [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.

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 66⅔%, 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 $^5\!/_8$ 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 $^5\!/_8$ 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 $^5\!/_8$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $4\frac{1}{2}$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 (1 020°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 ≤ 0.187 in.	t ≤ 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 ≤ 0.187 in. [Note (1)]	Welded Products, t ≤ 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 ≤ 5.00 mm [Note (1)]	Welded Products, t ≤ 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.

INTENTIONALLY LEFT BLANK

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 $^1/_8$ in. (3 mm).

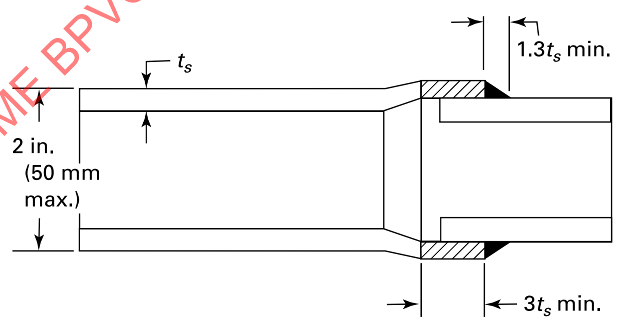
(h) The lap at the joint and the weld size shall meet the requirements of Figure 1.

(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



INTENTIONALLY LEFT BLANK

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.

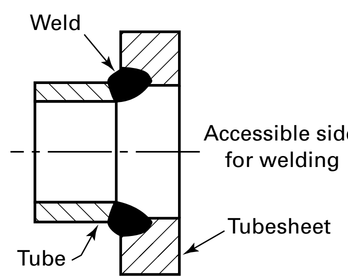
(e) The welding procedure specifications, the welders, and the welding operators shall be qualified in accordance with Section IX.

(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



After Welding

INTENTIONALLY LEFT BLANK

Case 2430
Use of A213/A213M-04 UNS S31060 Austenitic Stainless Steel Seamless Tubing and A240/A240M-04a$^{\varepsilon 1}$ 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 austentic stainless steel seamless tubes and A240/A240M-04a$^{\varepsilon 1}$ 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 66⅔%, 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 66⅔%, 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

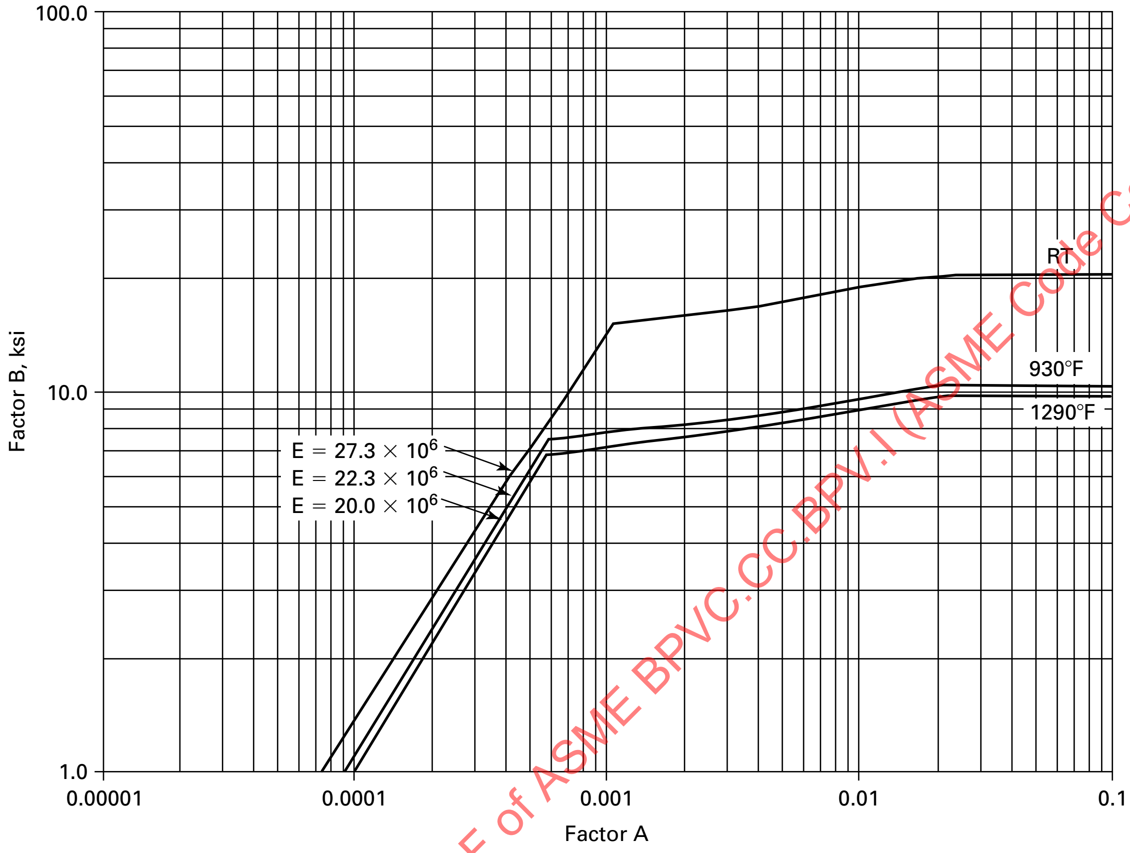


Figure 1M
Chart for Determining Shell Thickness of Components under External Pressure When Constructed of Alloy UNS S31060

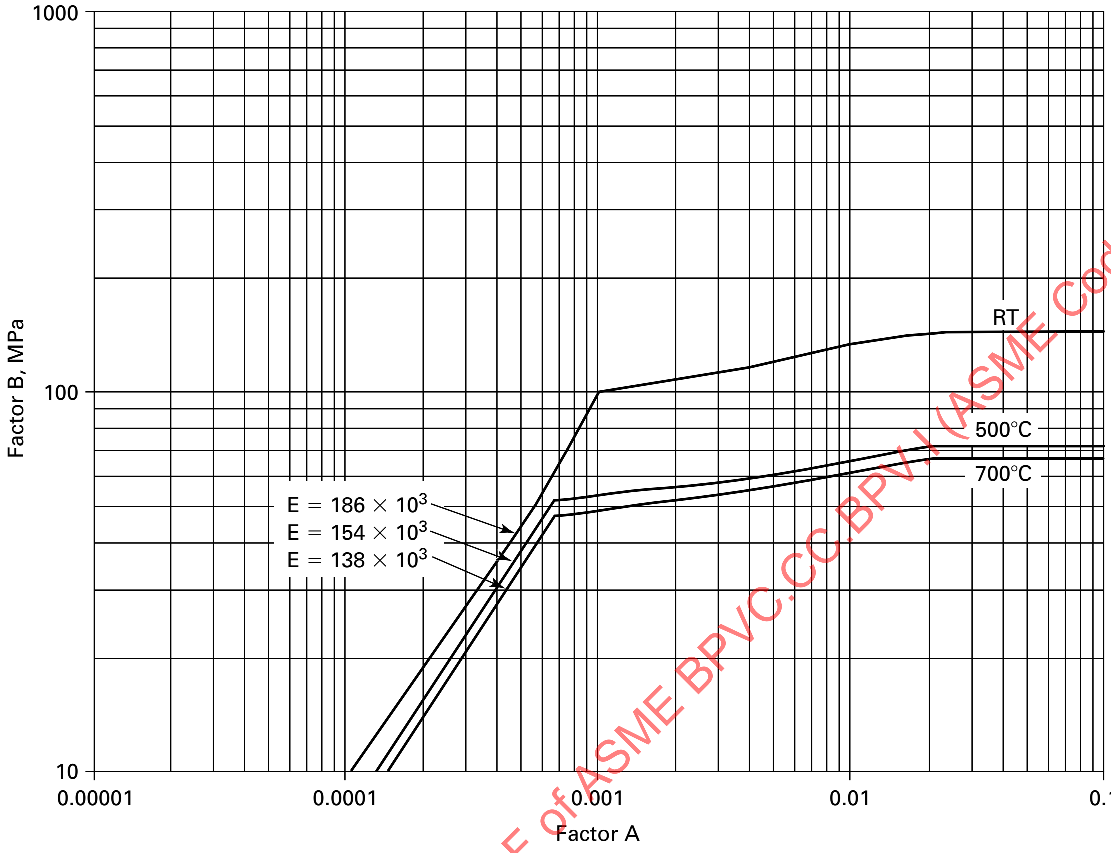


Table 2
Tabular Values for UNS S31060

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

INTENTIONALLY LEFT BLANK

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

INTENTIONALLY LEFT BLANK

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 l.

(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 66⅔% 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-½Mo-½Ni (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 (1 080°C) to 2,156°F (1 180°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 $66^2/_3$%, 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 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 $66^2/_3$%, 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 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.

INTENTIONALLY LEFT BLANK

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 4*D*, 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 66⅔%, 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 66⅔%, 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	B, ksi	Temp., °F	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	1.00 −05	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	1.00 −05	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	B, MPa	Temp., °C	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	1.00 −05	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	1.00 −05	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

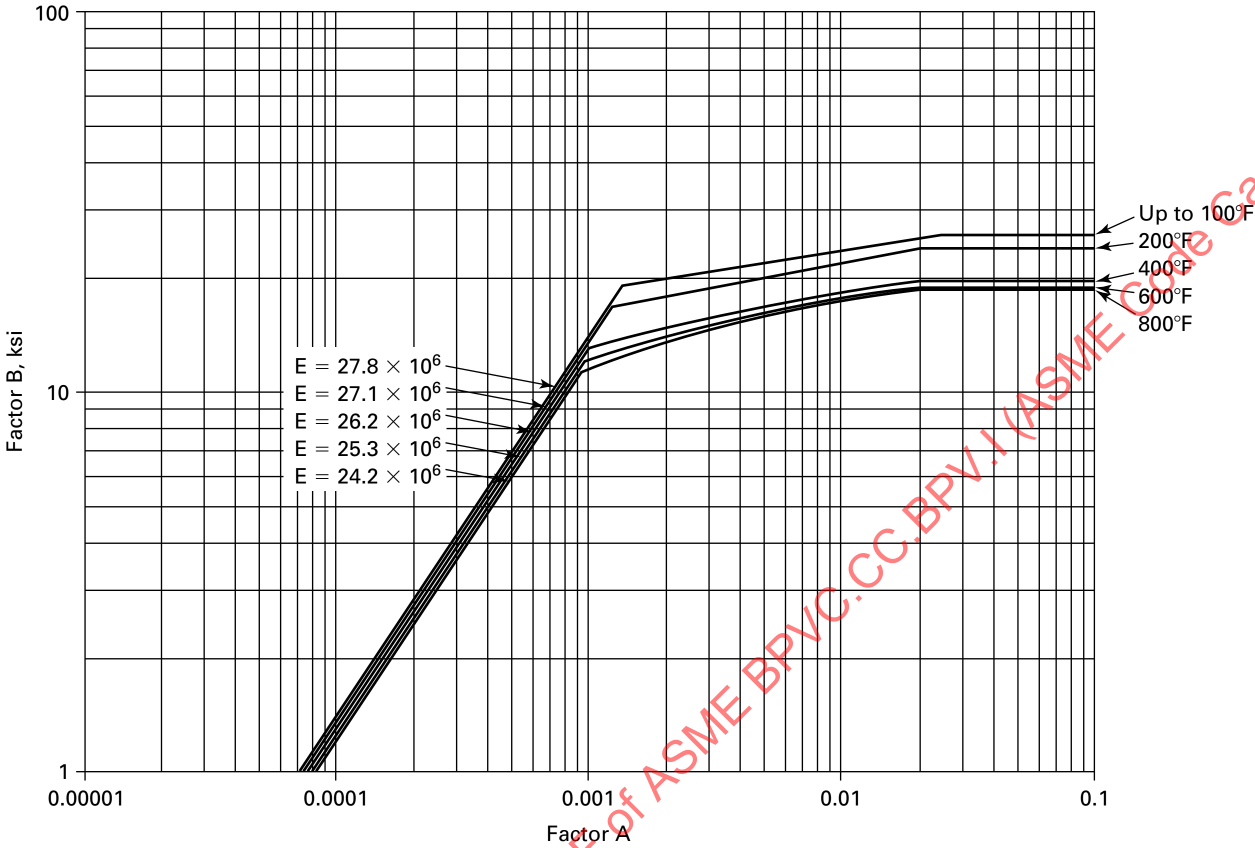
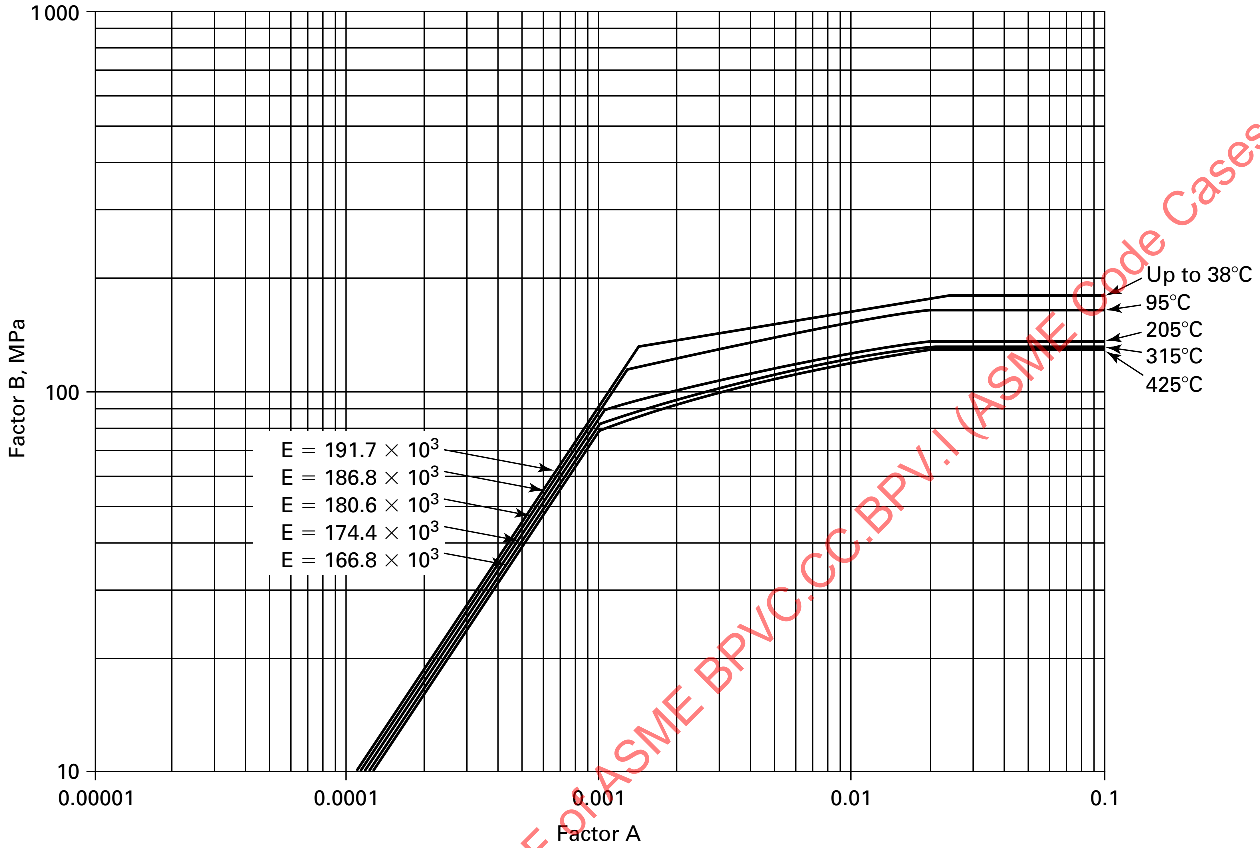


Figure 1M
Chart for Determining Shell Thickness of Components Under External Pressure When Constructed of Alloy UNS S31277



INTENTIONALLY LEFT BLANK

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

	Inclusion Type							
	A		B		C		D	
Zone [Note (1)]	Thin	Heavy	Thin	Heavy	Thin	Heavy	Thin	Heavy
Surface	1	1	1	$\frac{1}{2}$	1	1	1	$\frac{1}{2}$
Core	2	$1\frac{1}{2}$	2	1	2	$1\frac{1}{2}$	2	1

NOTE: (1) The *surface zone* is from the wire surface to $\frac{1}{3}$ 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 (2 050)	261 (1 800)	4.0

Table 4
Design Data for Yield Strength

	Yield Strength, ksi for Metal Temperature Not Exceeding		
Thickness, in.	100°F	200°F	300°F
0.04–0.06	261	254	230

Table 4M
Design Data for Yield Strength

	Yield Strength, MPa for Metal Temperature Not Exceeding				
Thickness, mm	40°C	65°C	100°C	125°C	150°C
1.0–1.5	1 800	1 800	1 740	1 670	1 580

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

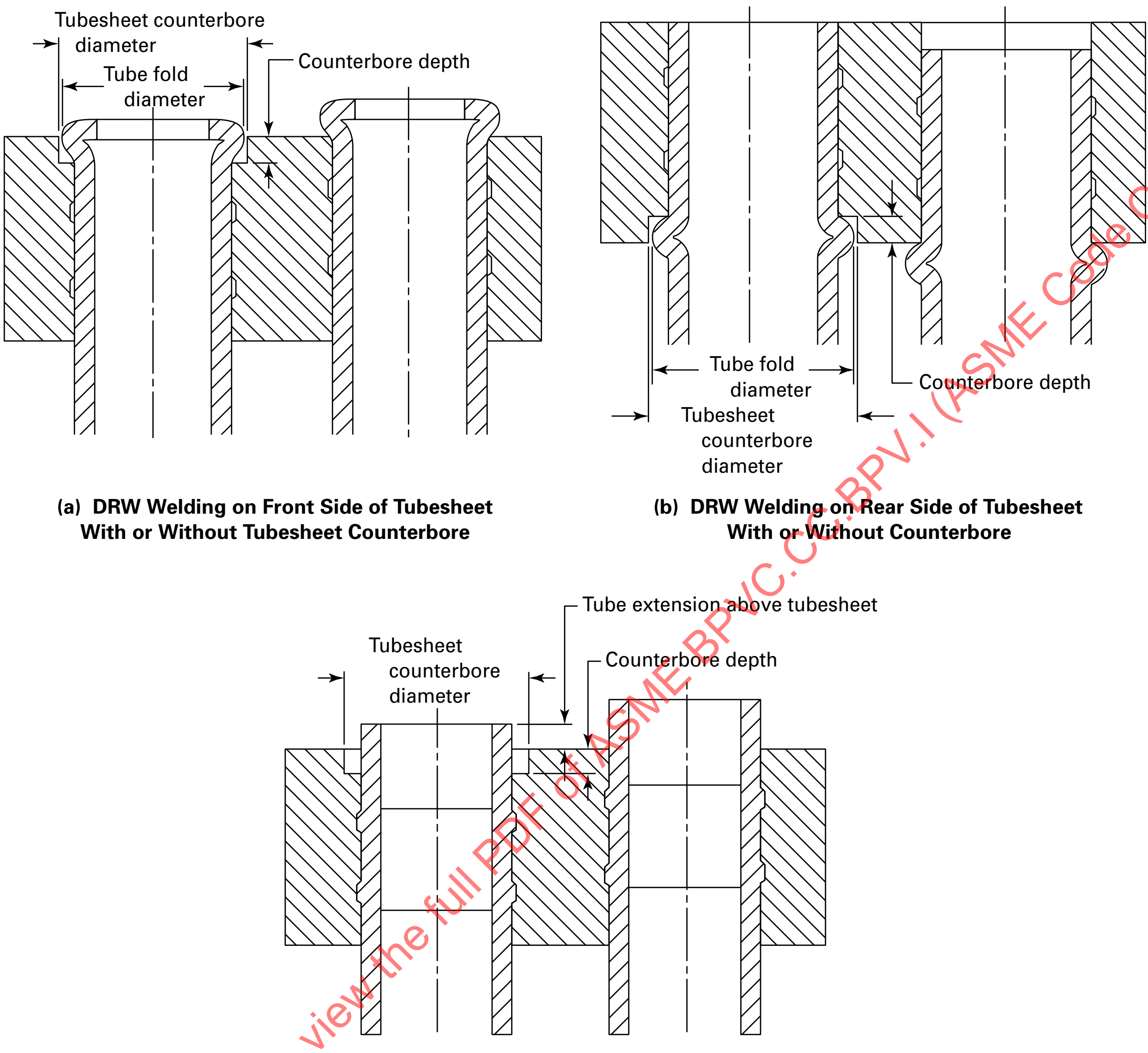
(i) a change of more than 5% in the pulse width from that qualified

(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-toTubesheet 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 (1 100 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.

INTENTIONALLY LEFT BLANK

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

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.

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

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.

INTENTIONALLY LEFT BLANK

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 66⅔%, 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 66⅔%, 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 2[1]

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.

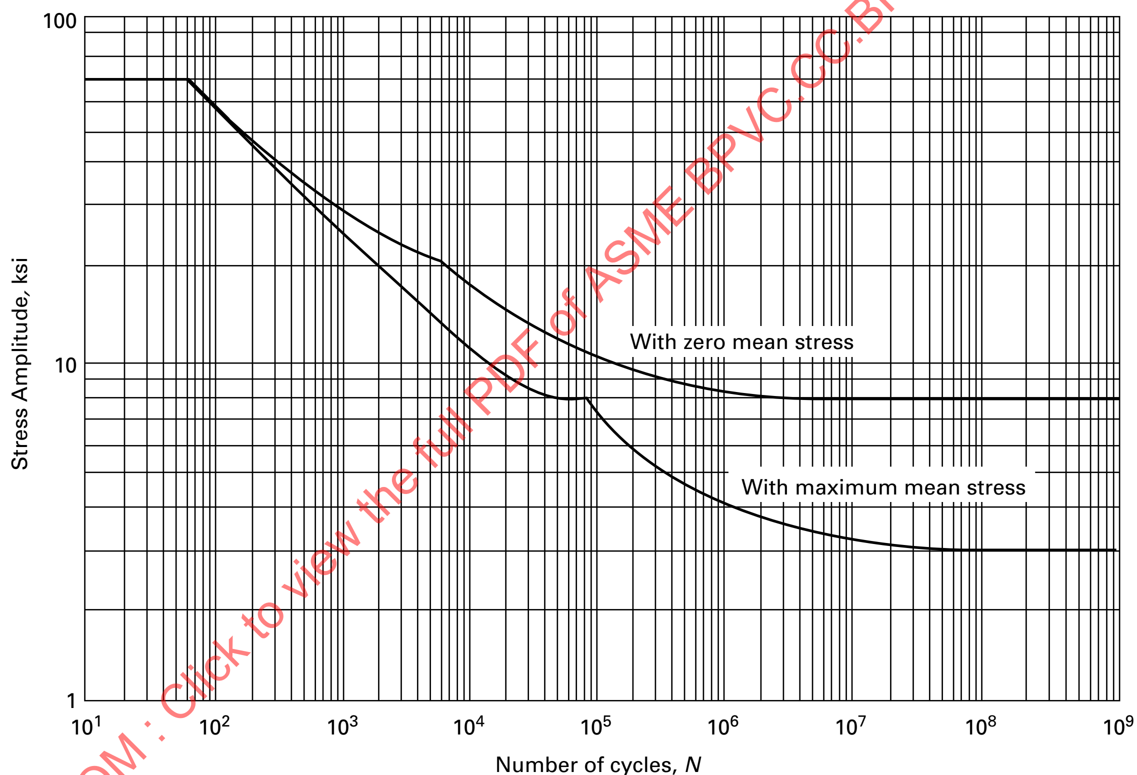
[1] This reinstated Case has been revised.

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

INTENTIONALLY LEFT BLANK

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 4*D* 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 66⅔% 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 66⅔% 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.

[1] The revised criterion of 3.5 on tensile strength was used in establishing the maximum allowable stress value.

INTENTIONALLY LEFT BLANK

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 transitions 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 $^3/_8$ in. thick and $1^1/_2$ in. wide or wider if necessary to capture all of the welds in a multilayer material, with a minimum of the lesser of $^1/_2$ 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 $^5/_{16}$ 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 $3\frac{1}{2}$ 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 perfomed 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 $3\frac{1}{2}$ 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} (7 860 kg/m^3)

(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: SA-789 Tube; Pipe, t < 0.40 in.	Division 1 Values, ksi: SA-789/SA-789M and ASTM A790/A790M for t ≥ 0.40 in.; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M	Division 2 Values, ksi: SA-789/SA-789M and ASTM A790/A790M for t < 0.40 in.	Division 2 Values, ksi: SA-789/SA-789M and ASTM A790/A790M for t ≥ 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: SA-789M Tube; Pipe, SA-789/SA-789M and ASTM A790/A790M for t < 10 mm	Division 1 Values, MPa: SA-789/SA-789M and ASTM A790/A790M for t ≥ 10 mm; and SA-240/SA-240M, ASTM A182/A182M, and ASTM A479/A479M	Division 2 Values, MPa: SA-789/SA-789M and ASTM A790/A790M for t < 10 mm	Division 2 Values, MPa: SA-789/SA-789M and ASTM A790/A790M for t ≥ 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 construction, 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 66⅔%, 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 66⅔%, 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 ($Y = D_o/D_t$) 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).

$$P_D = \left({}^2\!/_3\right) \times k_c \times S_y \times l_n(Y) \tag{1}$$

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).

$$P_D = \left({}^4\!/_3\right) \times k_c \times S_y \times l_n(Y) \tag{2}$$

(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:

$$P_m \le k_c \times S_y/1.5 \tag{3}$$

$$P_l \le k_b \times S_y \tag{4}$$

$$P_l + P_b \le \alpha \times k_b \times S_y/1.5 \tag{5}$$

$$P_l + P_b + Q \le 2 \times k_b \times S_y \tag{6}$$

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)

$$\log\sigma_{\text{ksi}} = -0.0263 \times (P/1000)^2 + 0.8159 \times (P/1000) - 4.6063$$

(SI Units)

$$\log\sigma_{\mathrm{MPa}} = -0.0263 \times (P/1000)^2 + 0.8159 \times (P/1000) - 3.7677$$

where

σ = stress, ksi (MPa)
P = Larson-Miller parameter
= $(T_C + 273.16) \times (20 - \log \varepsilon_{\min})$
= $(T_F/1.8 + 255.38) \times (20 - \log \varepsilon_{\min})$
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 shll 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 imtermediate 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:

$$vTr40 + 2.5\Delta vTr40 \leq 50°\text{F}\,(10°\text{C})$$

where

$vTr40$ = 40 ft-lb (54 J) minimum transition temperature before step cooling at minimum PWHT

$\Delta vTr40$ = 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 2¼Cr-1Mo-V Steel for Temperatures Not Exceeding 800°F (427°C) and 850°F (454°C)

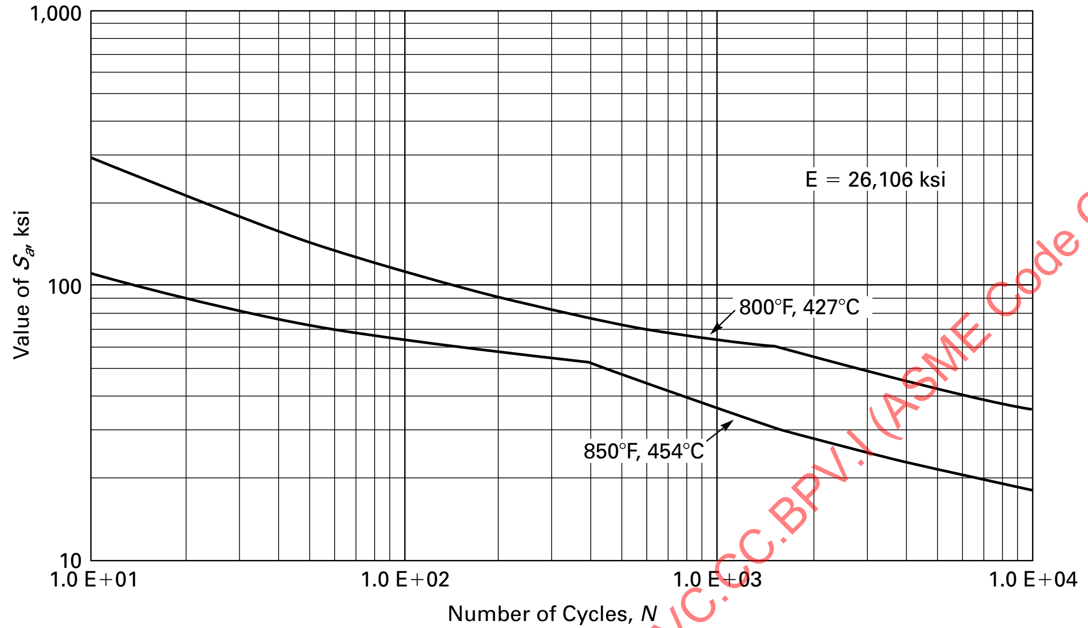


Figure 1M
Design Fatigue Curve for 2¼Cr-1Mo-V Steel for Temperatures Not Exceeding 800°F (427°C) and 850°F (454°C)

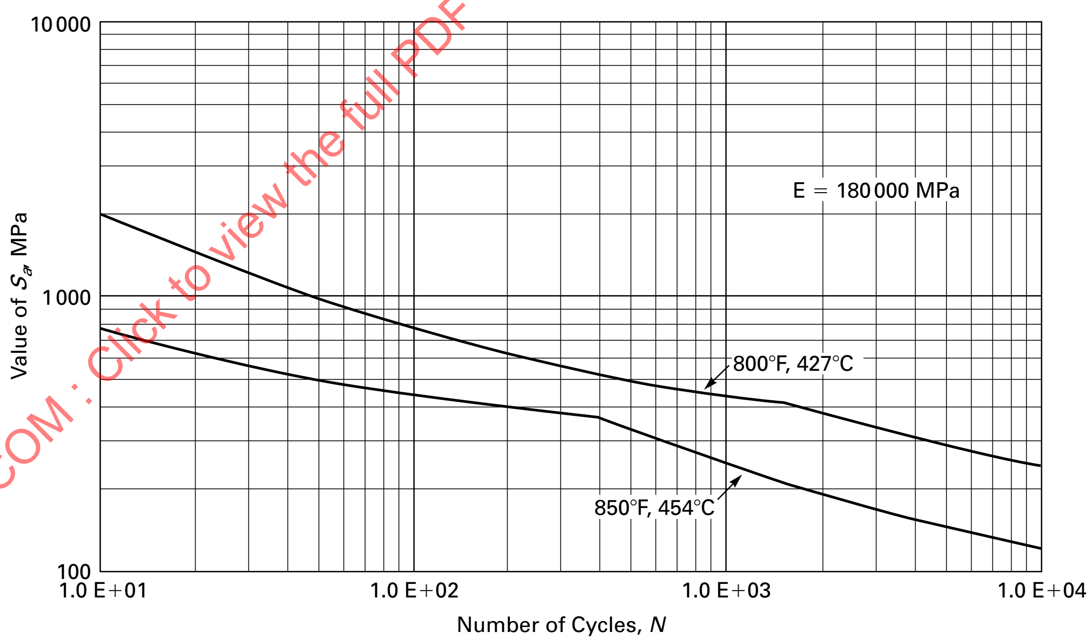


Table 3
Tabulated Values of S_a, From Figure 1

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 materiall 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	2 080
0.9	2 070
1.0	2 060
1.1	2 040
1.2	2 020
1.4	2 000
1.6	1 980
1.8	1 960
2.0	1 940
2.2	1 920
2.5	1 900
2.8	1 880
3.0	1 860
3.5	1 840
4.0	1 820
4.5	1 800
5.0	1 780
5.5	1 760
6.0	1 740

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 $66\frac{2}{3}$%, 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 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 $66\frac{2}{3}$%, 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 purposes only. The maximum design temperature is as stated in (d).

INTENTIONALLY LEFT BLANK

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 (1 050°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 66⅔%, 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 66⅔%, 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 gaskested 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 horizontally 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.

INTENTIONALLY LEFT BLANK

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.

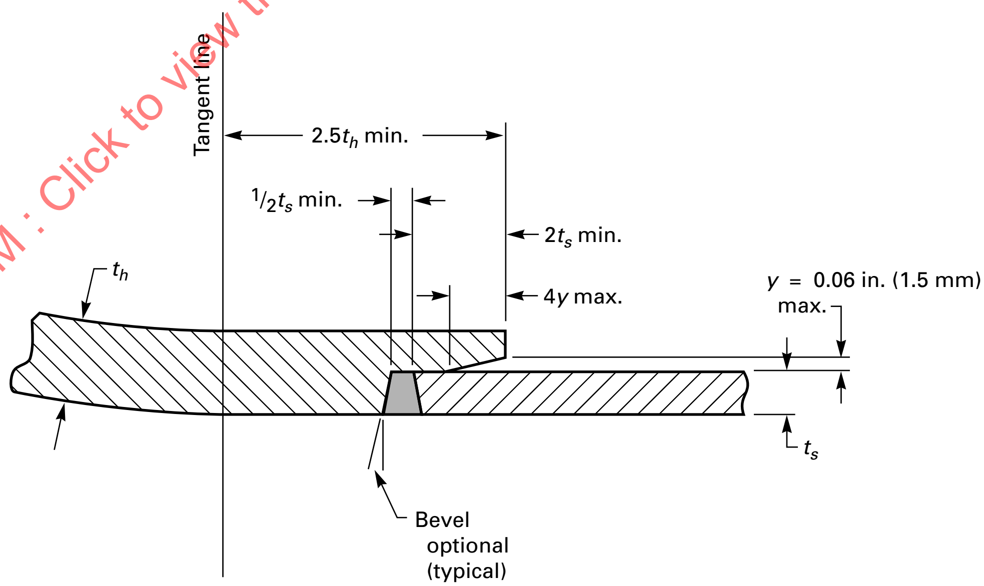
(i) The required thickness of the shell shall not exceed $\frac{3}{16}$ in. (5 mm).

(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



INTENTIONALLY LEFT BLANK

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 exhanger and by the integral underlying brazed structure.

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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 for $t_n/t \le 1.0$
= 54 for $t_n/t > 1.0$
B_2 = 210 for $t_n/t \le 1.0$
= 318 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
λ = $(d_m/D_m)(D_m/t)^{1/2}$
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) For $(d_m/D_m) > 0.5(D_m/t) \le 100$

(-b) For $(d_m/D_m) \le 0.5(D_m/t) \le 250$

(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, nonuniform-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:

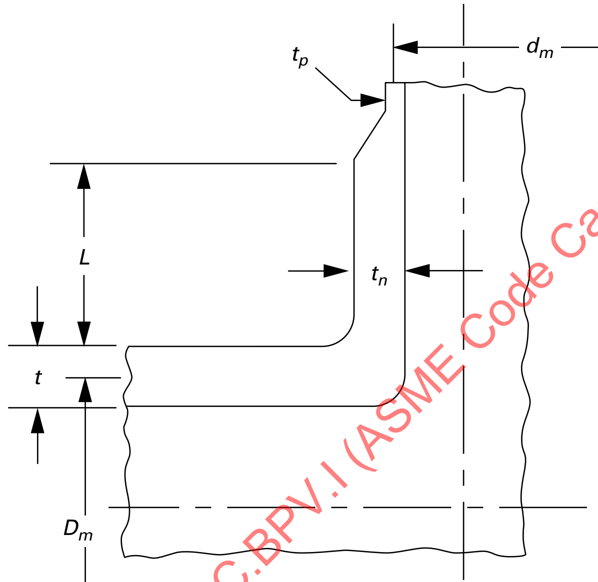
$$\frac{2 + 2\left(\frac{d_m}{D_m}\right)^{3/2}\left(\frac{t_n}{t}\right)^{1/2} + 1.25\lambda}{1 + \left(\frac{d_m}{D_m}\right)^{1/2}\left(\frac{t_n}{t}\right)^{3/2}} \le 2.95\left(\frac{t}{t_r}\right) \tag{1}$$

$$\frac{\left[B_1\left(\frac{t_n}{t}\right)^2 + 228\left(\frac{t_n}{t}\right)\left(\frac{d_m}{D_m}\right) + B_2\right]\lambda + 155}{108\lambda^2 + \left[228\left(\frac{d_m}{D_m}\right)^2 + 228\right]\lambda + 152} \geq (0.93 + 0.005\lambda)\left(\frac{t_r}{t}\right) \quad (2)$$

(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 references[1] 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.

INTENTIONALLY LEFT BLANK

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:*

$$C = 7.01\text{ E}{-9}\ (\text{in./cycle})(\text{ksi}-\text{in.}^{1/2})^{-m}$$
$$m = 3.26$$
$$G = 2.13\ \text{ksi}-\text{in.}^{1/2}$$
$$I = 1.83\ \text{ksi}-\text{in.}^{1/2}$$

ΔK_{th} need not be less than 0.67 ksi – in.$^{1/2}$.

(-b) *SI units:*

$$C = 1.31\text{ E}{-10}\ (\text{m/cycle})(\text{MPa}-\text{m}^{1/2})^{-m}$$
$$m = 3.26$$
$$G = 2.34\ \text{MPa}-\text{m}^{1/2}$$
$$I = 2.01\ \text{MPa}-\text{m}^{1/2}$$

ΔK_{th} need not be less than 0.73 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

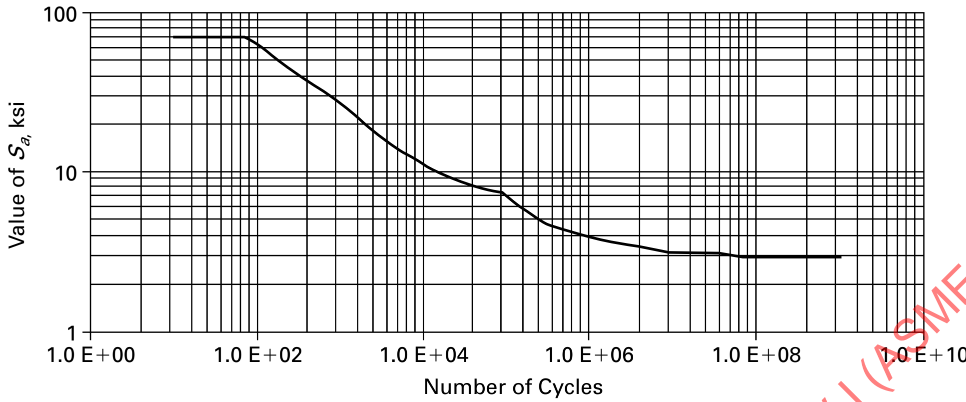
NOTE: (1) These values are provided for extrapolation only. The maximum design temperature is 225°F.

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

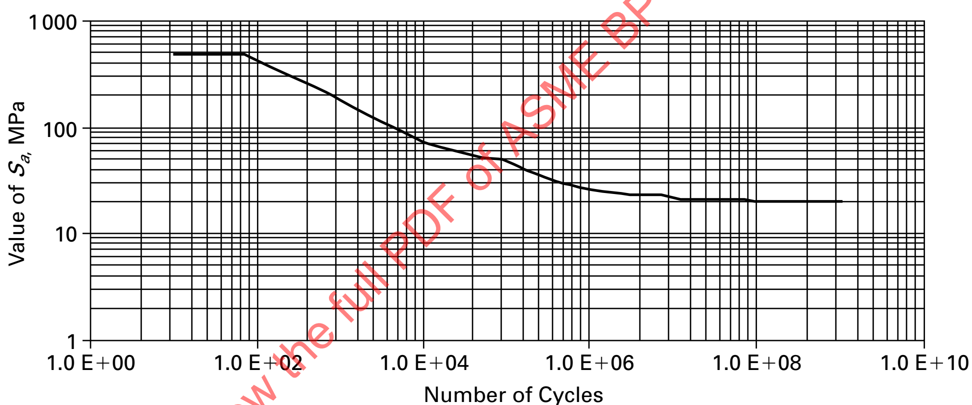
NOTE: (1) These values are provided for extrapolation only. The maximum design temperature is 107°C.

Figure 1
Design Fatigue Curve for Nonwelded 6061-T6 Aluminum Construction



GENERAL NOTE: Modulus of elasticity − E = 10 × 10^6 psi.

Figure 1M
Design Fatigue Curve for Nonwelded 6061-T6 Aluminum Construction



GENERAL NOTE: Modulus of elasticity − E = 69 × 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 × 10^J, e.g., 5.0E + 2 = 5 × 10^2
(b) Interpolation between tabular values is permissible based upon data representation by straight lines on a log-log plot. Accordingly, for Si > S > Sj, (N/Ni) = $(Nj/Ni)^{[\log (Si/S)/\log(Si/Sj)]}$

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

Case 2571-1
Use of SA-240, Grades 304L and 316L in Thickness Less Than $^1/_4$ 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 $^1/_4$ 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 $^1/_4$ in. (6 mm) may be used in Section IV construction 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.

INTENTIONALLY LEFT BLANK

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)
A691-1$^1/_4$Cr Cl. 22	SA-387 Gr. 11 Cl. 1	850 (454)
A691-1$^1/_4$Cr Cl. 22	SA-387 Gr. 11 Cl. 2	850 (454)
A691-2$^1/_4$Cr Cl. 22	SA-387 Gr. 22 Cl. 1	850 (454)
A691-2$^1/_4$Cr Cl. 22	SA-387 Gr. 22 Cl. 2	850 (454)
A691-91 Cl. 42	SA-387 Gr. 91 Cl. 2	1,000 (538)

INTENTIONALLY LEFT BLANK

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 66⅔% 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 66⅔% 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$^2/_3$%, 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$^2/_3$%, 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 66⅔%, 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 66⅔%, 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.

INTENTIONALLY LEFT BLANK

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

	Metal Temperature Not Exceeding, °F						
Grade / Condition	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

	Metal Temperature Not Exceeding, °C										
Grade / Condition	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.

INTENTIONALLY LEFT BLANK

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)
$t \leq 5/8$ in. (16 mm)	66.5 (460)	64.5 (445)
5/8 in. (16 mm) < $t \leq 0.79$ in. (20 mm)	64.5 (445)	62.5 (430)

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $^{1}\!/_{8}$ 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 ±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."

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 66⅔%, 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 66⅔%, 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 (1 100 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.

INTENTIONALLY LEFT BLANK

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)

$$\dot{\varepsilon} \leq \frac{3(10)^{-8}}{\text{hr}} \tag{1}$$

(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, $\dot{\varepsilon}_0$ [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, $\dot{\varepsilon}_0$, 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, $\dot{\varepsilon}_0$ [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, $\dot{\varepsilon}_0$, 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 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:

$$P_L + P_b + Q + F \leq \left(S_h + S_{yc}\right) \quad (2)$$

(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.

$$\dot{\varepsilon}_c = \frac{\dot{\varepsilon}_{oc}}{1 - D_c} \quad (3)$$

$$\log_{10} \quad \dot{\varepsilon}_{oc} = -\left\{A_0 + \left(\frac{A_1 + A_2 S_l + A_3 S_l^2 + A_4 S_l^3}{T}\right)\right\} \quad (4)$$

$$S_l = \log_{10}(\sigma_e) \quad (5)$$

$$\sigma_e = \frac{1}{\sqrt{2}}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2\right]^{0.5} \quad (6)$$

$$D_c = \int_0^t \dot{D}_c dt \leq 1.0 \quad (7)$$

$$\dot{D}_c = \Omega_m \dot{\varepsilon}_{oc} \quad (8)$$

$$\Omega_m = \Omega_n^{\delta+1} \quad (9)$$

$$\Omega_n = \text{max. } [(\Omega - n), \quad 3.0] \quad (10)$$

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%

$$\log_{10} \quad \Omega = B_0 + \left(\frac{B_1 + B_2 S_l + B_3 S_l^2 + B_4 S_l^3}{T} \right) \tag{11}$$

$$n = -\left(\frac{A_2 + 2A_3 S_l + 3A_4 S_l^2}{T} \right) \tag{12}$$

$$\delta = \beta \left(\frac{3p}{\sigma_e} - 1.0 \right) \tag{13}$$

$$p = \frac{\sigma_1 + \sigma_2 + \sigma_3}{3} \tag{14}$$

(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.

$$L_{cwf} = L_{caf} \cdot \left(\frac{\beta_{cf} \cdot \Delta\varepsilon_{peq} \cdot N}{\exp\left[\beta_{cf} \cdot \Delta\varepsilon_{peq} \cdot N\right] - 1} \right), \quad \Delta\varepsilon_{peq} > 0 \tag{15}$$

$$L_{cwf} = L_{caf}, \quad \Delta\varepsilon_{peq} = 0 \tag{16}$$

(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.

$$L_{cwf} = L_{caf} \cdot \left[\frac{\beta_{cf} \cdot \sum_{i=1}^{k} \Delta\varepsilon_{peq,k}}{\exp\left[\beta_{cf} \cdot \sum_{i=1}^{k} \Delta\varepsilon_{peq,k}\right] - 1} \right], \quad \Delta\varepsilon_{peq} > 0 \tag{17}$$

$$L_{cwf} = L_{caf}, \quad \Delta\varepsilon_{peq} = 0 \tag{18}$$

(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 $^1/_3$

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

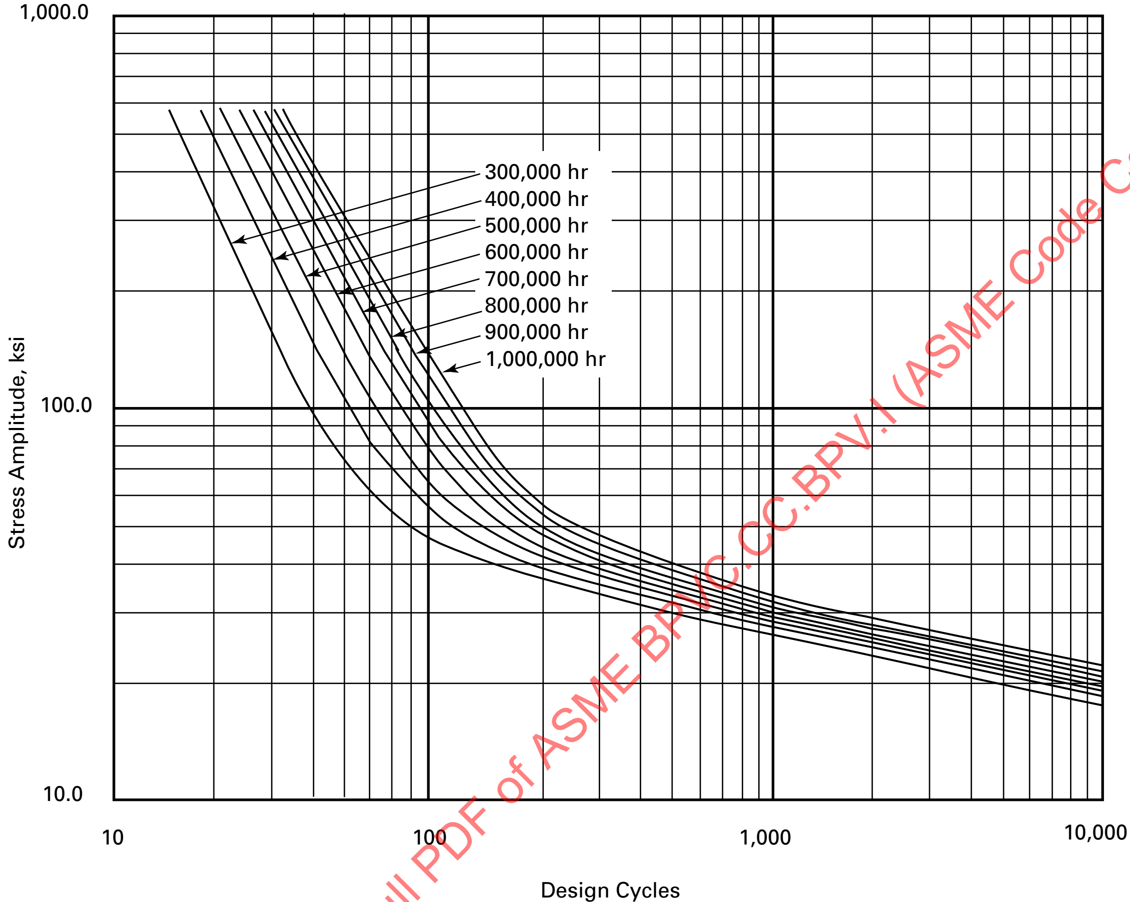
T = temperature

Ω = uniaxial Omega damage parameter

Ω_m = multiaxial Omega damage parameter

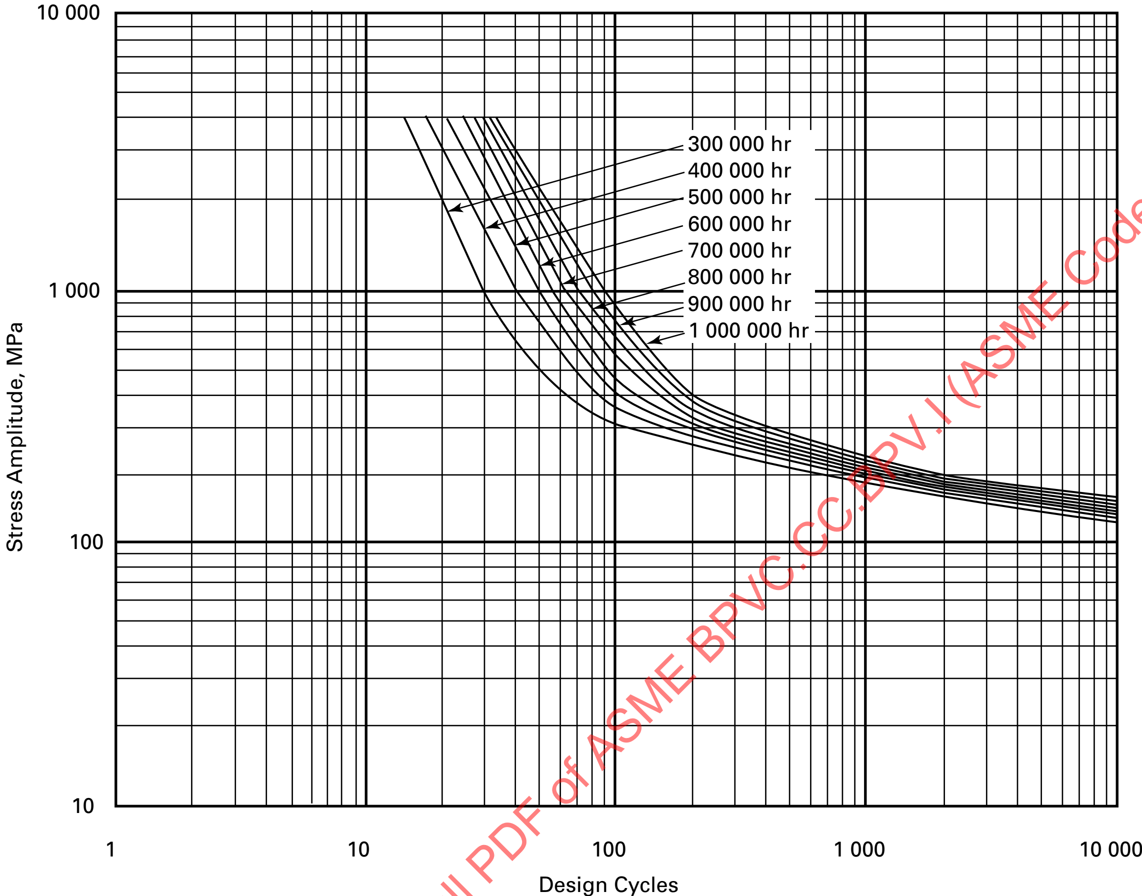
Ω_n = adjusted uniaxial Omega damage parameter

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	1354	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	2 237	2 983	3 729	4 474	5 220	5 966	6 711	7 457
156	2 473	3 298	4 122	4 947	5 771	6 596	7 420	8 244
153	2 735	3 646	4 558	5 469	6 381	7 292	8 204	9 115
150	3 023	4 031	5 039	6 047	7 054	8 062	9 070	10 078
148	3 343	4 457	5 571	6 685	7 799	8 913	10 028	11 142
145	3 696	4 927	6 159	7 391	8 623	9 855	11 086	12 318
142	4 086	5 448	6 809	8 171	9 533	10 895	12 257	13 619
140	4 517	6 023	7 528	9 034	10 540	12 045	13 551	15 057
137	4 994	6 659	8 323	9 988	11 652	13 317	14 982	16 646
135	5 521	7 362	9 202	11 042	12 883	14 723	16 564	18 404
132	6 104	8 139	10 174	12 208	14 243	16 278	18 312	20 347
130	6 749	8 998	11 248	13 497	15 747	17 996	20 246	22 495
127	7 461	9 948	12 435	14 922	17 409	19 896	22 383	24 870
125	8 249	10 998	13 748	16 498	19 247	21 997	24 747	27 496
123	9 120	12 160	15 200	18 240	21 279	24 319	27 359	30 399
120	10 083	13 443	16 804	20 165	23 526	26 887	30 248	33 609
118	11 147	14 863	18 579	22 294	26 010	29 726	33 441	37 157
116	12 324	16 432	20 540	24 648	28 756	32 864	36 972	41 080
114	13 625	18 167	22 709	27 250	31 792	36 334	40 875	45 417
112	15 064	20 085	25 106	30 127	35 149	40 170	45 191	50 212
110	16 654	22 205	27 757	33 308	38 860	44 411	49 962	55 514
108	18 412	24 550	30 687	36 825	42 962	49 100	55 237	61 375
106	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 482°C and 180 000 MPa, respectively.

Table 4
Stress Amplitude Versus Plastic Strain

Alternating Equivalent Stress Amplitude		
ksi	MPa	Equivalent Plastic Strain Amplitude
577.5	3 982	0.02000000
440.7	3 039	0.01480000
339.2	2 339	0.01095200
263.9	1 820	0.00810400
207.9	1 434	0.00599700
166.3	1 147	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.

INTENTIONALLY LEFT BLANK

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.

Table 1
Maximum Allowable Stress Values

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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

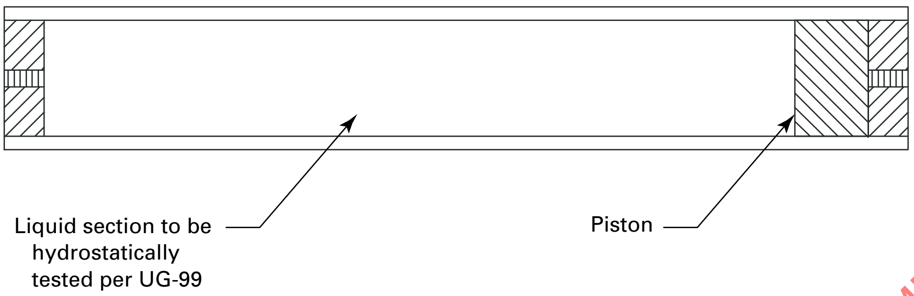
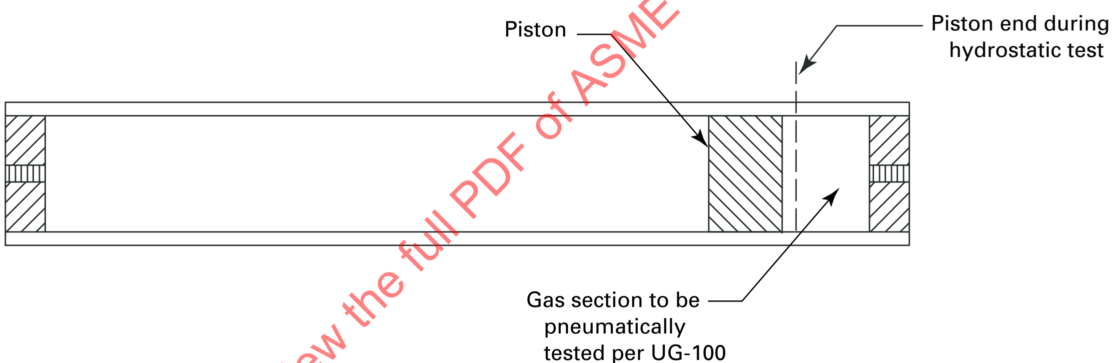


Figure 2
Pneumatic Test



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	1 980	2 140
0.9	1 960	2 120
1	1 940	2 100
1.1	1 920	2 080
1.2	1 900	2 060
1.4	1 860	2 020
1.6	1 820	1 980
1.8	1 800	1 960
2	1 780	1 930
2.2	1 750	1 900
2.5	1 720	1 860
2.8	1 680	1 830
3	1 660	1 800
3.5	1 620	1 760
4	1 580	1 720
4.5	1 560	1 680
5	1 520	1 640
5.5	1 480	1 620
6	1 460	1 600
6.5	1 440	1 580
7	1 420	1 560
8	1 400	1 540
9	1 380	1 520
10	1 360	1 500
11	1 340	1 480
12	1 320	1 460

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 $^5/_8$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 66⅔%, 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 66⅔%, 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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	
	$t \leq 0.187$ in.	$t > 0.187$ 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	
	$t \leq 5$ mm	$t > 5$ 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.
(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) $t \le 0.5$ in.
(2) 0.5 in. $< t \le 1$ 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) $t \le 13$ mm
(2) 13 mm $< t \le 25$ 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.

INTENTIONALLY LEFT BLANK

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 construction 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 66⅔%, 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 66⅔%, 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/ Temper	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)

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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:

$$1150^\circ\text{F}\,(620^\circ\text{C})\text{ and below},\ y = 0.4$$

$$1200^\circ\text{F}\,(650^\circ\text{C}),\ y = 0.5$$

(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 6*t* 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 ft^3 (0.11 m^3).

(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.

INTENTIONALLY LEFT BLANK

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 fo 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 66⅔% 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 66⅔% 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 chemcial 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 (1 050°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 (1 050°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 66⅔%, 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 66⅔%, 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.

INTENTIONALLY LEFT BLANK

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 multiiplied 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 1548-2008[1] 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.

[1] See 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.

INTENTIONALLY LEFT BLANK

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 $^3\!/_{16}$ 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 $^3\!/_{16}$ 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	*14.1, 14.1*
1,050	*11.0, 11.0*
1,100	*8.6, 8.6*
1,150	*6.7, 6.7*
1,200	*5.2, 5.2*
1,250	*4.1, 4.1*
1,300	*3.2, 3.2*
1,350	*2.4, 2.4*
1,400	*1.8, 1.8*
1,450	*1.4, 1.4*
1,500	*1.1, 1.1*
1,550	*0.76, 0.76*
1,600 [Note (3)]	*0.59, 0.59*
1,650	*0.47, 0.47*
1,700	*0.37, 0.37*
1,750	*0.29, 0.29*
1,800	*0.23, 0.23*
1,850 [Note (4)]	*0.19, 0.19*

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 accceptable. 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, 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	*109, 109*
550	*87.0, 87.0*
575	*69.6, 69.6*
600	*55.6, 55.6*
625	*44.5, 44.5*
650	*35.5, 35.5*
675	*28.4, 28.4*
700	*22.8, 22.8*
725	*17.3, 17.3*
750	*13.9, 13.9*
775	*11.2, 11.2*
800	*8.97, 8.97*
825	*6.12, 6.12*
850	*4.92, 4.92* [Note (3)]
875	*3.96, 3.96*
900	*3.20, 3.20*
925	*2.59, 2.59*
950	*2.10, 2.10*
975	*1.71, 1.71*
1 000	*1.39, 1.39* [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 accceptable. The stress values in this range exceed 66⅔%, 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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

$$W = 2A_{mL}S_a$$

(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 $W = 2A_{mL}S_a$ can overstress the clamp.

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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

Table 1
Maximum Allowable Stress for Grade UNS S43932, Seamless SA-268 Tube, Plate, and Strip

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

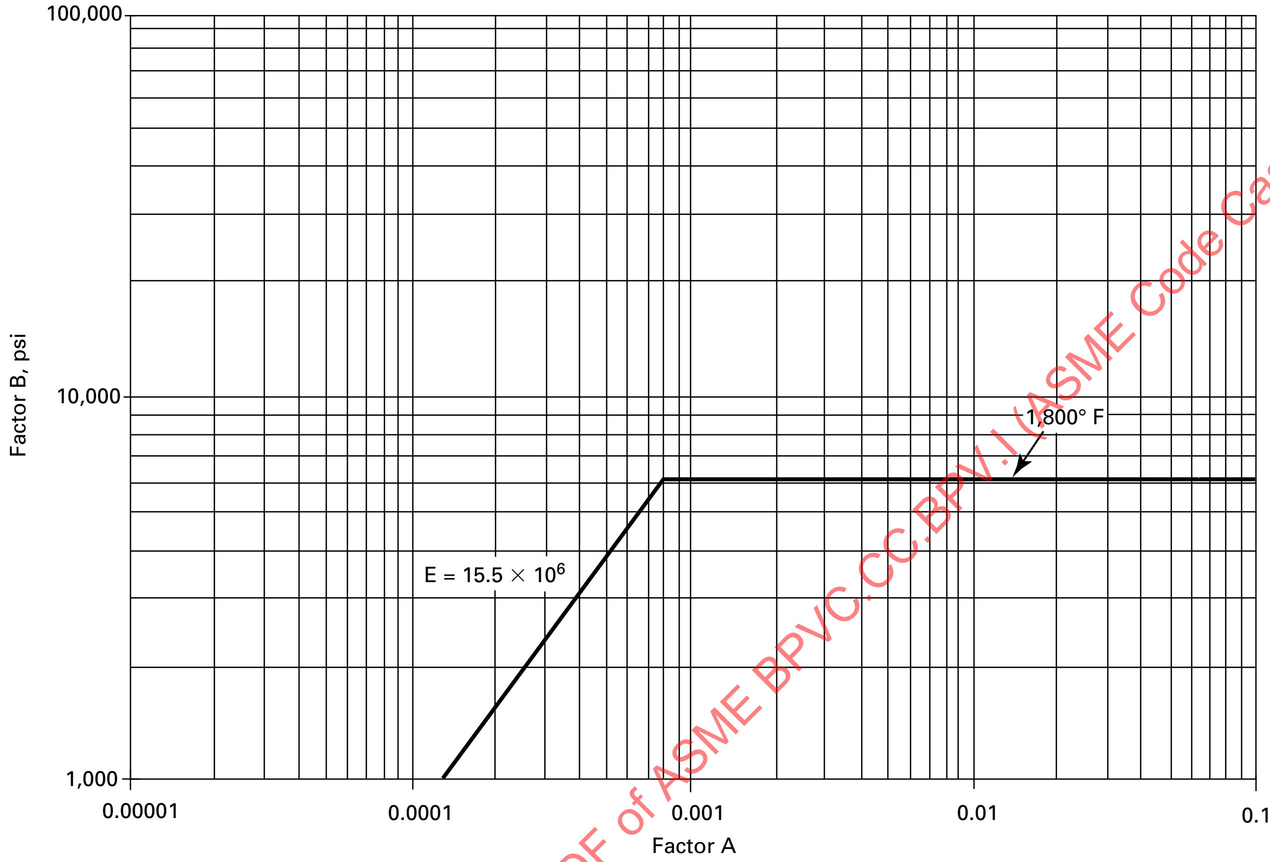


Figure 1M
External Pressure Chart up to 982°C

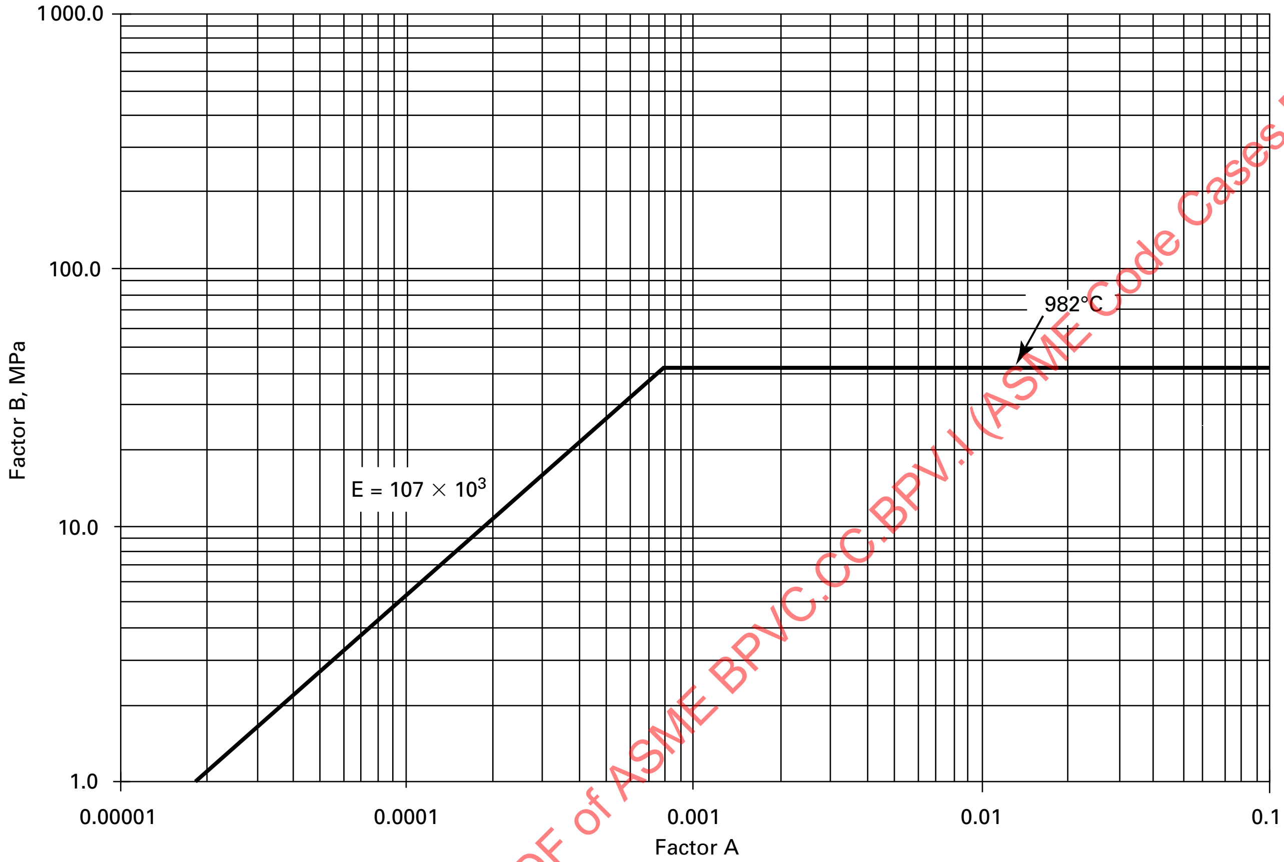


Table 1
Tabular Values for Figure 1

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

INTENTIONALLY LEFT BLANK

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 constrction 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.

INTENTIONALLY LEFT BLANK

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 1¼Cr-½Mo-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

INTENTIONALLY LEFT BLANK

Case 2676
Alternative Procedure for Calculating Allowable Axial Compressive Stress in Cylindrical Shells Constructed of $2\frac{1}{4}$Cr-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 $2\frac{1}{4}$Cr-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 $2\frac{1}{4}$Cr-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

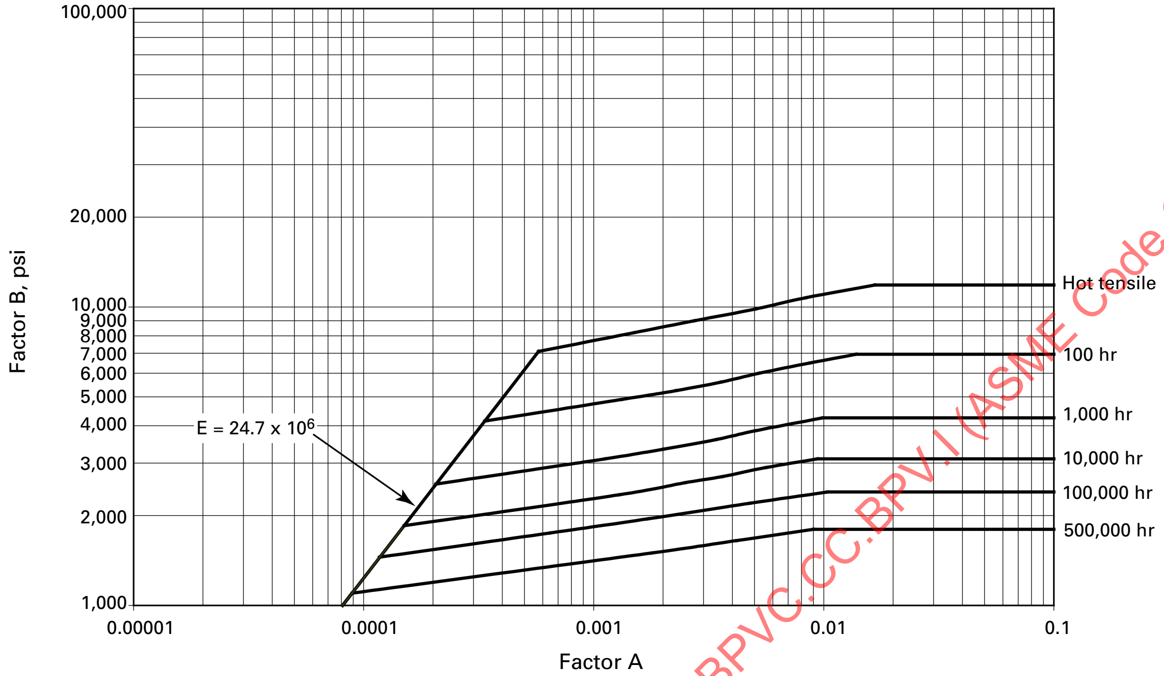


Figure 1M
External Pressure Chart for 2¼Cr-1Mo Steel (Annealed) at 538°C

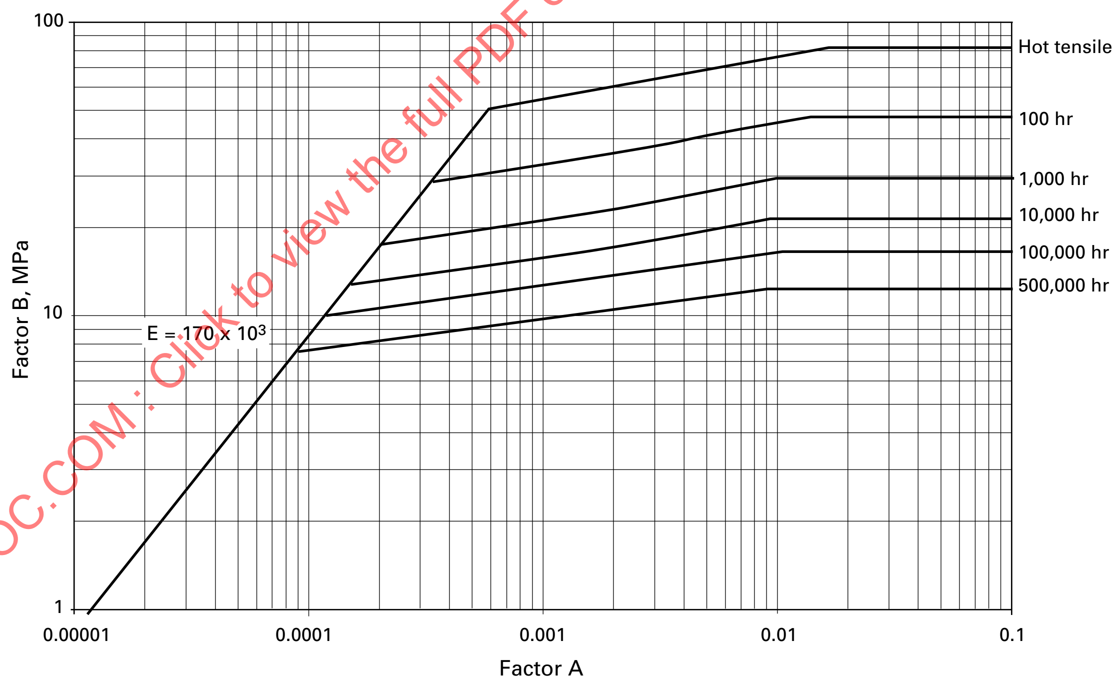


Table 1
Tabular Values for Figure 1

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		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	500,000	1.00E−05	1
	1.00E−01	48		8.10E−05	7
1,000	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 peformed 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 $^3/_8$ 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 guideway 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

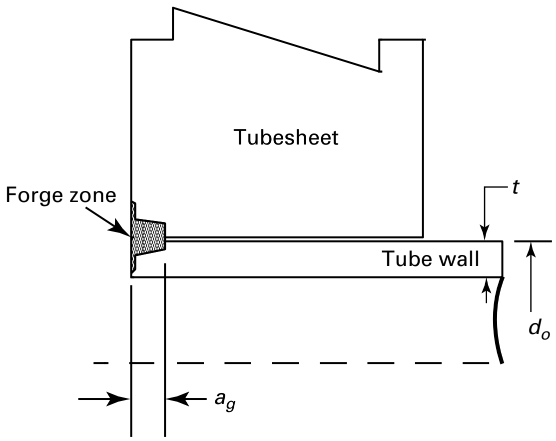


Figure 2
Weld Leg Dimension After Optional Surface Cleanup

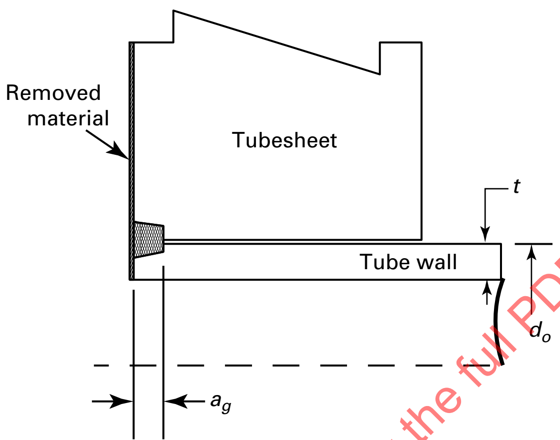


Figure 3
Example of Probe With Flutes

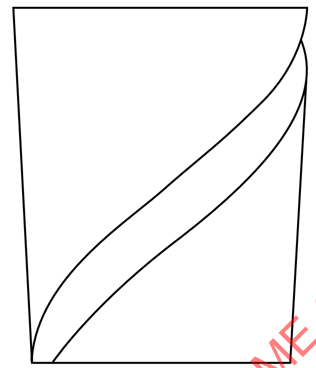


Figure 4
Example of Probe With Thread

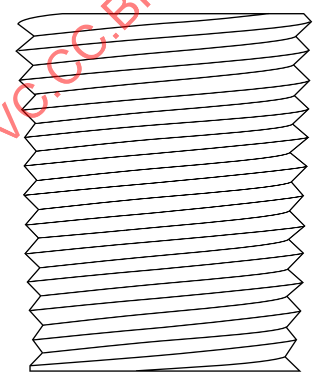
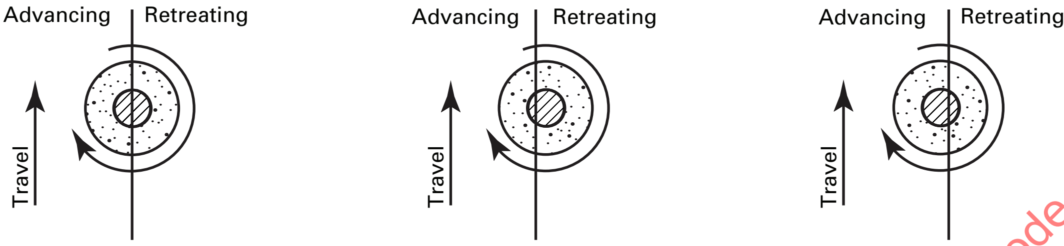


Figure 5
Typical Centered Seam Alignment, Good Mixing by Placing Seam on Advancing Side of Probe, Poor Mixing by Placing Seam on Retreating Side of Probe



(a) Centered Seam Alignment **(b) Good Mixing** **(c) Poor Mixing**

INTENTIONALLY LEFT BLANK

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 $^{5}/_{16}$ 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.

INTENTIONALLY LEFT BLANK

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 0.6*W*.

(-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 0.6*W*.

(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 0.86*W* to 0.54*W*.

(6) In Table 5.4, Load Combination (4), change 1.7*W* to 1.1*W*.

(7) In Table 5.5, Load Combination (3), change 1.4*W* to 0.86*W*.

(8) In Table 5.5, Load Combination (4), change 2.7*W* to 1.7*W*.

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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

Case 2681-1
Use of 9Ni, 8Ni, and 5Ni-$^1/_4$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-$^1/_4$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-$^1/_4$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

INTENTIONALLY LEFT BLANK

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

$$K_1 = \frac{5}{5 - 0.304 \quad \ln(T)}$$

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

$$K_2 = \frac{3}{3 - 0.1303 \quad \ln(T)}$$

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

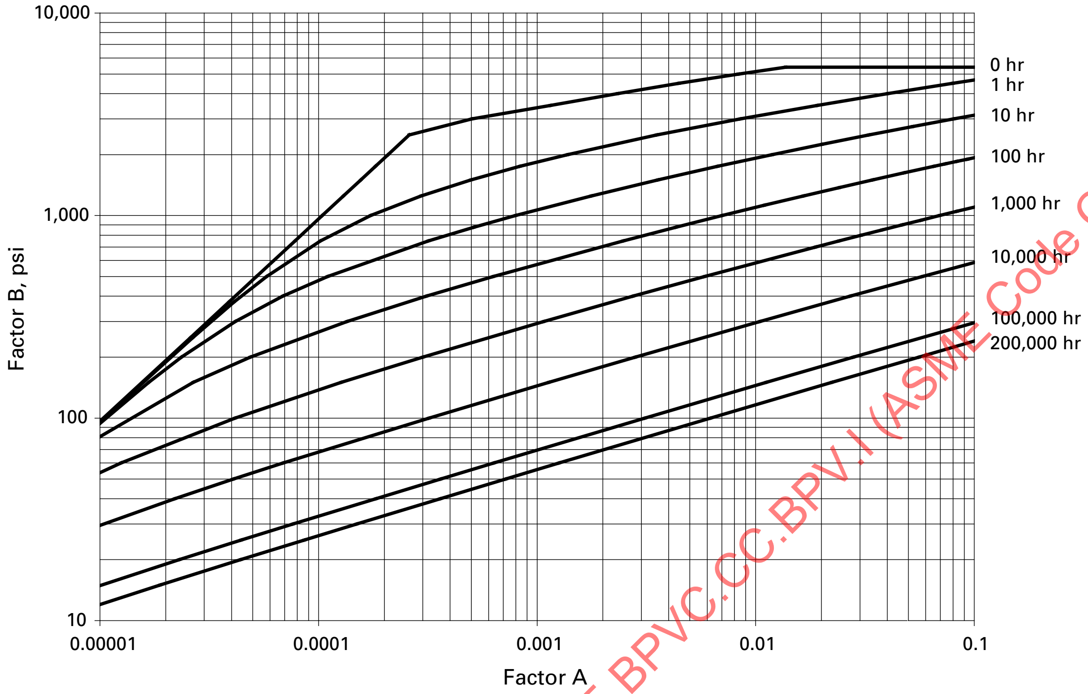


Table 1
Tabular Values at 1650°F For Figure 1

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			
	1.56E −04	1500		3.29E −02	2500	10,000	1.00E −05	29.5
	1.82E −04	1750		5.21E −02	2750		2.20E −05	40
	2.08E −04	2000		8.06E −02	3000		4.08E −05	50
	2.60E −04	2500		1.00E −01	3130		6.90E −05	60
	5.04E −04	3000					3.20E −04	100
	1.15E −03	3500	100	1.00E −05	81		1.13E −03	150
	2.33E −03	4000		2.67E −05	150		2.81E −03	200
	4.46E −03	4500		4.87E −05	200		1.05E −02	300
	8.34E −03	5000		1.35E −04	300		2.71E −02	400
	1.37E −02	5400		3.12E −04	400		5.78E −02	500
	1.00E −01	5400		6.29E −04	500		1.00E −01	586
				2.48E −03	750			
1	1.00E −05	96		4.30E −03	875	100,000	1.00E −05	14.9
	2.66E −05	250		7.03E −03	1000		2.31E −05	20
	4.12E −05	375		1.10E −02	1125		4.43E −05	25
	5.78E −05	500		1.65E −02	1250		7.64E −05	30
	1.02E −04	750		2.41E −02	1375		1.83E −04	40
	1.73E −04	1000		3.43E −02	1500		3.62E −04	50
	2.94E −04	1250		4.78E −02	1625		6.34E −04	60
	4.98E −04	1500		6.54E −02	1750		3.11E −03	100
	8.34E −04	1750		7.38E −02	1800		1.12E −02	150
	1.38E −03	2000		8.31E −02	1850		2.80E −02	200
	3.52E −03	2500		9.33E −02	1900		1.00E −01	296
	8.52E −03	3000		1.00E −01	1930			
	1.91E −02	3500				200,000	1.00E −05	12
	4.01E −02	4000	1000	1.00E −05	53.7		1.89E −05	15
	7.98E −02	4500		1.25E −05	60		4.40E −05	20
	1.00E −01	4670		4.14E −05	100		8.61E −05	25
				1.27E −04	150		1.50E −04	30
10	1.00E −05	94		3.00E −04	200		3.61E −04	40
	1.67E −05	150		1.07E −03	300		7.18E −04	50
	2.36E −05	200		2.75E −03	400		1.26E −03	60
	4.16E −05	300		5.83E −03	500		6.21E −03	100
	6.87E −05	400		1.88E −02	700		2.23E −02	150
	1.10E −04	500		2.40E −02	750		5.59E −02	200
	3.18E −04	750		3.04E −02	800		1.00E −01	240

Figure 1M
External Pressure Chart for Stainless Steel Alloy UNS S30815 At 900°C

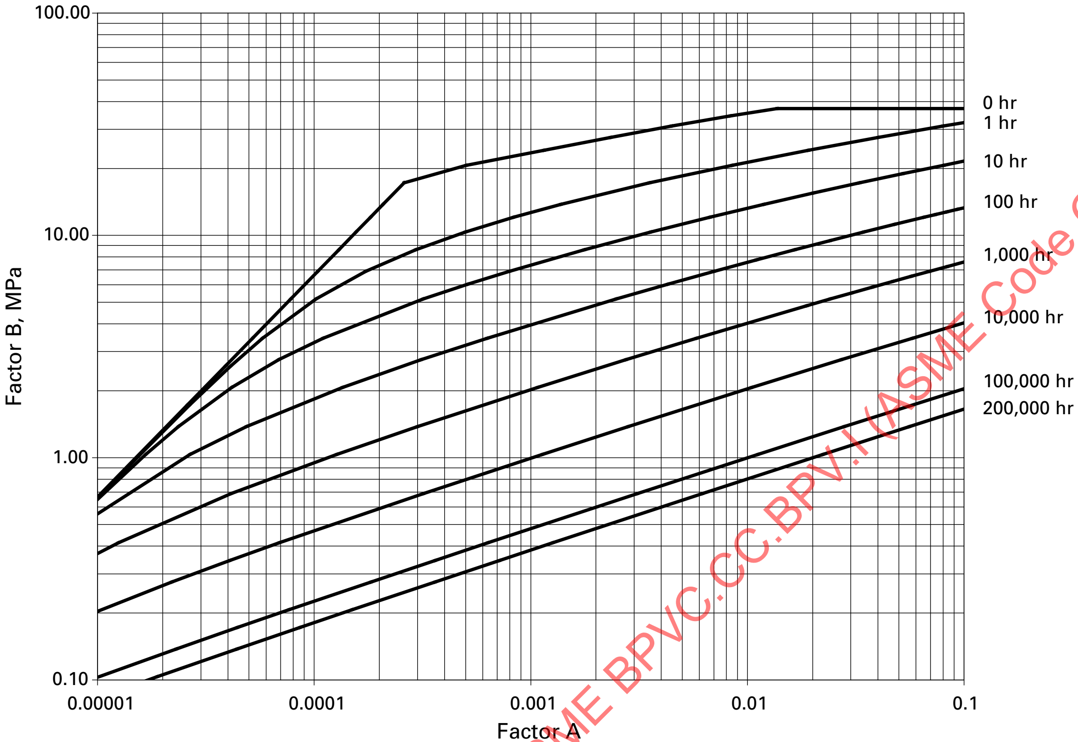


Table 1M
Tabular Values at 900°C For Figure 1M

Time, hr	A	B, MPa
0	1.00E −05	0.67
	2.60E −05	1.72
	3.90E −05	2.59
	5.20E −05	3.45
	7.80E −05	5.17
	1.04E −04	6.90
	1.30E −04	8.62
	1.56E −04	10.34
	1.82E −04	12.07
	2.08E −04	13.79
	2.60E −04	17.24
	5.04E −04	20.69
	1.15E −03	24.13
	2.33E −03	27.58
	4.46E −03	31.03
	8.34E −03	34.48
	1.37E −02	37.23
	1.00E −01	37.23
1	1.00E −05	0.66
	2.66E −05	1.72
	4.12E −05	2.59
	5.78E −05	3.45
	1.02E −04	5.17
	1.73E −04	6.90
	2.94E −04	8.62
	4.98E −04	10.34
	8.34E −04	12.07
	1.38E −03	13.79
	3.52E −03	17.24
	8.52E −03	20.69
	1.91E −02	24.13
	4.01E −02	27.58
	7.98E −02	31.03
	1.00E −01	32.20
10	1.00E −05	0.65
	1.67E −05	1.03
	2.36E −05	1.38
	4.16E −05	2.07
	6.87E −05	2.76
	1.10E −04	3.45
	3.18E −04	5.17
10	5.12E −04	6.03
	7.96E −04	6.90
	1.77E −03	8.62
	3.57E −03	10.34
	6.71E −03	12.07
	1.19E −02	13.79
	2.01E −02	15.51
	3.29E −02	17.24
	5.21E −02	18.96
	8.06E −02	20.69
	1.00E −01	21.58
100	1.00E −05	0.56
	2.67E −05	1.03
	4.87E −05	1.38
	1.35E −04	2.07
	3.12E −04	2.76
	6.29E −04	3.45
	2.48E −03	5.17
	4.30E −03	6.03
	7.03E −03	6.90
	1.10E −02	7.76
	1.65E −02	8.62
	2.41E −02	9.48
	3.43E −02	10.34
	4.78E −02	11.20
	6.54E −02	12.07
	7.38E −02	12.41
	8.31E −02	12.76
	9.33E −02	13.10
	1.00E −01	13.31
1000	1.00E −05	0.37
	1.25E −05	0.41
	4.14E −05	0.69
	1.27E −04	1.03
	3.00E −04	1.38
	1.07E −03	2.07
	2.75E −03	2.76
	5.83E −03	3.45
	1.88E −02	4.83
	2.40E −02	5.17
	3.04E −02	5.52
1000	3.79E −02	5.86
	4.68E −02	6.21
	5.72E −02	6.55
	6.93E −02	6.90
	8.34E −02	7.24
	1.00E −01	7.58
10,000	1.00E −05	0.20
	2.20E −05	0.28
	4.08E −05	0.34
	6.90E −05	0.41
	3.20E −04	0.69
	1.13E −03	1.03
	2.81E −03	1.38
	1.05E −02	2.07
	2.71E −02	2.76
	5.78E −02	3.45
	1.00E −01	4.04
100,000	1.00E −05	0.10
	2.31E −05	0.14
	4.43E −05	0.17
	7.64E −05	0.21
	1.83E −04	0.28
	3.62E −04	0.34
	6.34E −04	0.41
	3.11E −03	0.69
	1.12E −02	1.03
	2.80E −02	1.38
	1.00E −01	2.04
200,000	1.00E −05	0.08
	1.89E −05	0.10
	4.40E −05	0.14
	8.61E −05	0.17
	1.50E −04	0.21
	3.61E −04	0.28
	7.18E −04	0.34
	1.26E −03	0.41
	6.21E −03	0.69
	2.23E −02	1.03
	5.59E −02	1.38
	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.

INTENTIONALLY LEFT BLANK

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/m^3)

(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 – 1 000	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
1 000	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	$m^2/sec \times 10^{-6}$
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
1 000	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
1 000	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 66⅔% 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 $66^2/_3$% 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

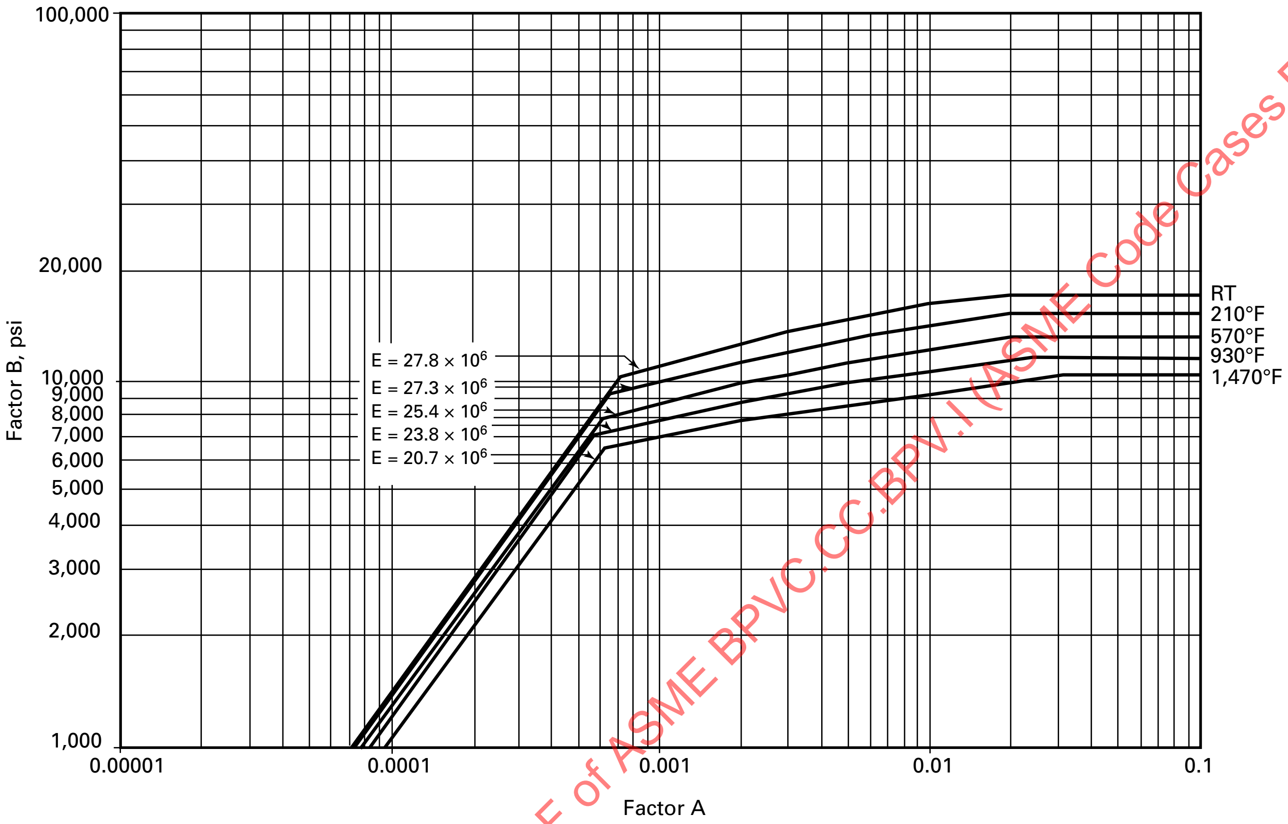
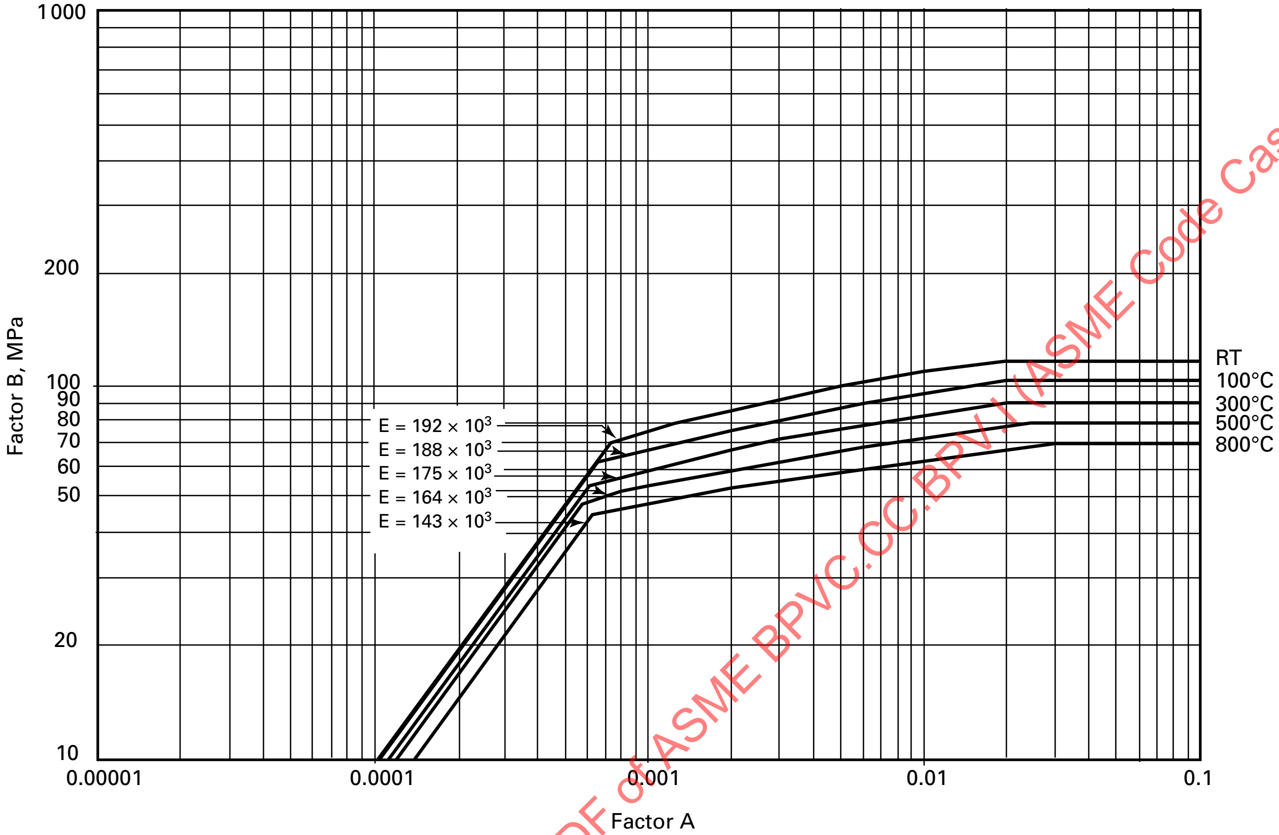


Figure 1M
Chart for Determining Shell Thickness of Components under External Pressure Developed for 47Ni-23Cr-23Fe-7W, UNS N06674



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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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

INTENTIONALLY LEFT BLANK

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 $1\frac{1}{2}$ (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).

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $\frac{1}{2}$ 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

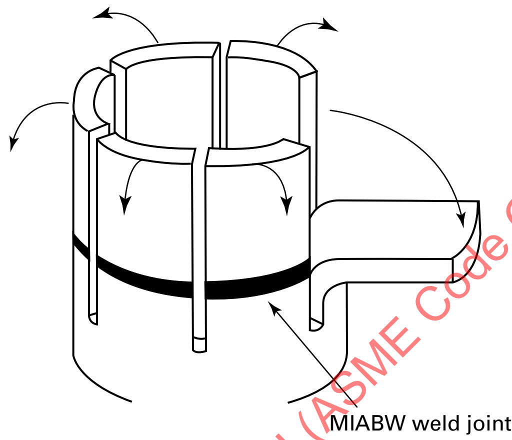
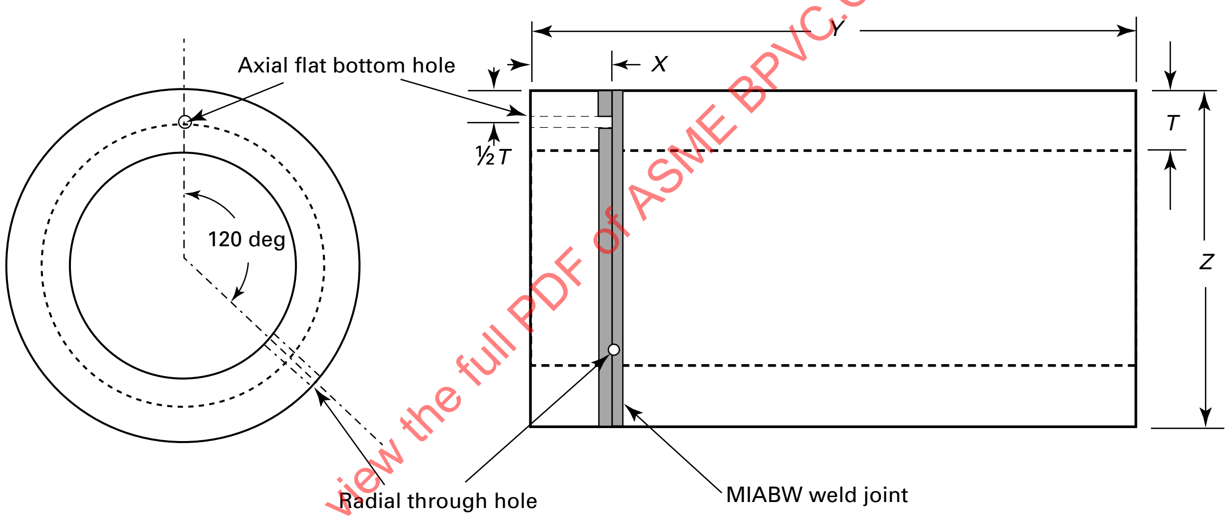


Figure 2
Reference Examination Block



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 $Z \geq 0.9 \times$ Tube O.D. and $\leq 1.5 \times$ 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 ±10% from that qualified	X	...
Change in programmed arc stabilization current greater than ±10% from that qualified	X	...
Change in programmed arc rotation current greater than ±10% from that qualified	X	...
Change in programmed cleaning/upset current greater than ±10% from that qualified	X	...
Change in programmed arc initiation time greater than ±10% from that qualified	X	...
Change in programmed arc stabilization time greater than ±10% from that qualified	X	...
Change in programmed arc rotation time greater than ±10% from that qualified	X	...
Change in programmed upset time greater than ±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 ±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

INTENTIONALLY LEFT BLANK

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 CO_2 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 $\frac{1}{2}$ 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.

INTENTIONALLY LEFT BLANK

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 in. (10 mm) for $t_s \leq 1\frac{1}{2}$ in. (38 mm)

r = $0.25t_s$ for $t_s > 1\frac{1}{2}$ in. (38 mm) but need not be greater than $\frac{3}{4}$ 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

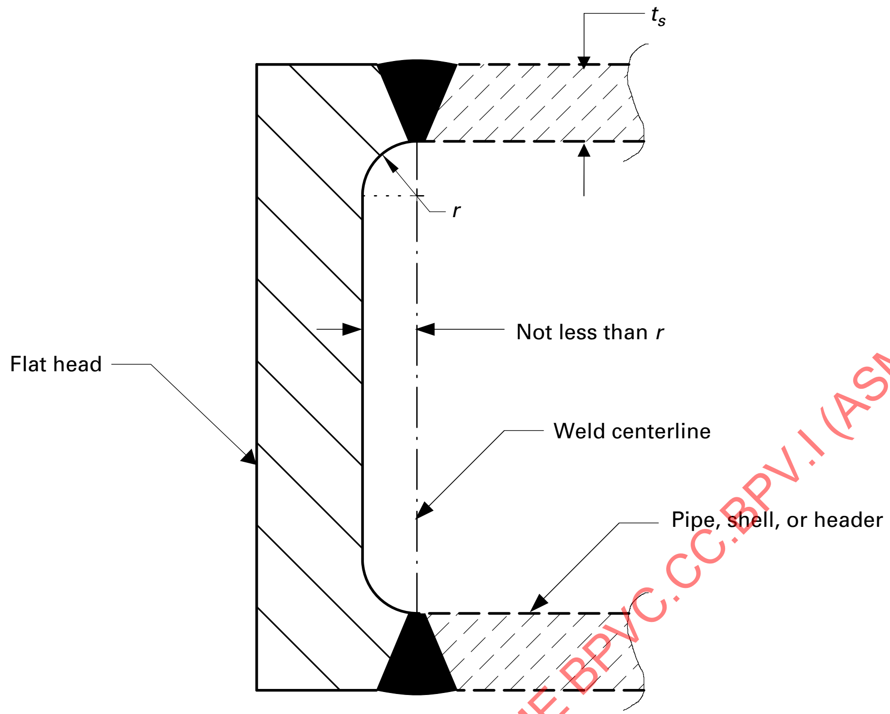


Figure 2
Machined Flat Head Tensile Specimen Location

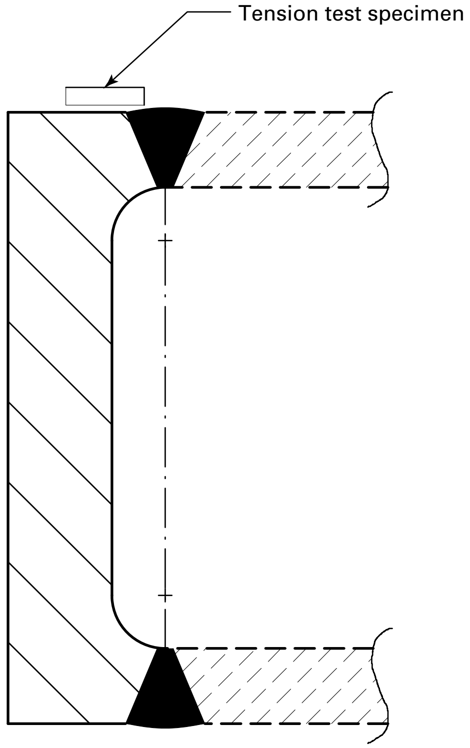
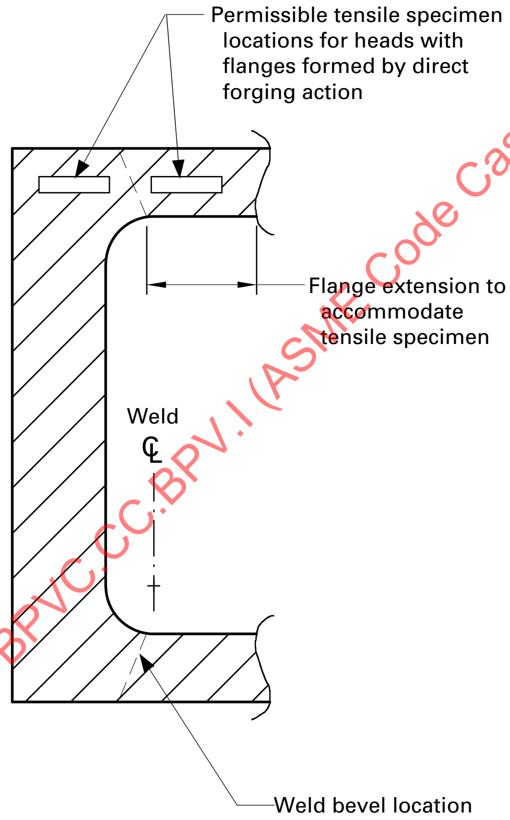


Figure 3
Flat Head with Flange Formed by Direct Forging Action, Tensile Specimen Locations



INTENTIONALLY LEFT BLANK

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 ± 0.3 ksi (1 000 bar ± 20 bar) and 2,085°F ± 18°F (1 140°C ± 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 $^1/_{16}$ 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 $^1/_{16}$ in. (1.6 mm) long for material less than $^5/_8$ in. (16 mm) thick, greater than $^1/_8$ in. (3.2 mm) long for material from $^5/_8$ in. (16 mm) thick to under 2 in. (50 mm) thick, and $^3/_{16}$ in. (4.8 mm) long for material 2 in. (50 mm) thick or greater

(-b) rounded indications with dimensions greater than $^1/_8$ in. (3.2 mm) for thicknesses less than $^5/_8$ in. (16 mm) and greater than $^3/_{16}$ in. (4.8 mm) for thicknesses $^5/_8$ in. (16 mm) or greater

(-c) four or more rounded indications in a line separated by $^1/_{16}$ in. (1.6 mm) or less, edge to edge

(-d) ten or more rounded indications in any 6 in.^{2} (3 900 mm^2) 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 $^1/_8$ 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

	C	*m*
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:

$$P_{dyn} \leq 1.25 P_D S_{yO} / S_{yD} \quad (1)$$

$$P_{dyn} \leq P_t \quad (2)$$

where

$$P_{dyn} = P_{\text{static}} + \left(P_{\text{peak}} - P_{\text{static}}\right)(DLF) \quad (3)$$

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.

INTENTIONALLY LEFT BLANK

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 (1 100°C) minimum for $^1\!/_2$ 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 $^1\!/_2$ 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 4*D* (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 4*t* 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 4*t* 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} (8 072 kg/m^3)

(2) melting range: 2,350°F to 2,484°F (1 288°C to 1 362°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

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	1 034
65	1 034
100	1 034
150	1 034
200	1 030
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.

INTENTIONALLY LEFT BLANK

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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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) (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 ______ (4) (DOT/UN Spec.) ______ (6) (Manufacturer's serial No.) ______ (7) (CRN) ______ (8) (Drawing No.) ______ (10) (National Bd. No.) ______ (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) Year to ______ (11) Addenda (if applicable) (Date) ______ (12) Code Case Nos. ______ (13) Capacity, liters (gallons)

6. Shell ______ (18) Material (Spec. No., Grade) ______ (19) Min. Required Thk. ______ (20) Corr. Allow. ______ (16) Diameter I.D. ______ (16) Length (overall)

7. Seams ______ (21) Long. (Welded, Dbl., Sngl., Lap, Butt) ______ (22) R.T. (Spot or Full) ______ (22) Eff. (%) ______ (25) H.T. Temp. ______ (25) Time (hr) ______ (23) Girth, (Welded, Dbl., Sngl., Lap, Butt) ______ (24) R.T. (Spot, Partial, or Full) ______ (16) No. of Courses

8. Heads: (a) Material ______ (15) (25) (29) (Spec. No., Grade) (b) Material ______ (Spec. No., Grade)

	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)
(a)		(26)	(20)	(27)	(28)					
(b)										

If removable, bolts used (describe other fastenings) ______ (30) (Material, Spec. No., Gr., Size, No.)

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:

Purpose (Inlet, Outlet, Drain)	No.	Diameter or Size	Type	Material	Nom. Thk.	Reinforcement Material	How Attached	Location
(37)		(38)	(38)	(18)	(42)	(43)	(44)	(46)
			(39)					
			(44)	(40)				

11. Supports: Skirt ______ (47) (Yes or no) 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 ______ (Name of part, item number, Manufacturer's name, and identifying stamp)
______ (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 Commision Number and Endorsement)

(01/12)

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) (52) (Name of Regulatory Agency and Regulation Met)
4. Type ______ (5) (DOT/UN Spec.) ______ (6) (Manufacturer's serial No.) ______ (7) (CRN)
______ (10) (National Bd. No.) ______ (8) (Drawing No.) ______ (9) (53) (Drawing prepared by) ______ (Year built)
5. ASME Code, Section XII ______ (11) [Edition and Addenda (if applicable) (date)] ______ (12) (Code Case No.) ______ (4) Class ______ (13) (52) Capacity
6. Shell: (a) No. of course(s) ______ (14) (b) Overall length ______ (15)

Course(s)			Material	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat A, B & C)			Heat Treatment	
No.	Diameter	Length	Spec./Grade or Type	Min.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
	(16)	(17)	(18)	(19)	(20)	(21)	(22)		(23)	(24)		(25)	
				(52)									

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.)

	Location (Top, Bottom, Ends)	Thickness		Radius		Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure		Category A		
		Min.	Corr.	Crown	Knuckle					Convex	Concave	Type	Full, Spot, None	Eff.
(a)		(26)	(20)	(27)	(28)								(29)	
(b)			(52)											

If removable, bolts used (describe other fastenings) ______ (30) (Material Spec. No., Grade, Size, No.)

8. MAWP (31) (52) ______ (internal) ______ (external) at max. temp. ______ (32) (internal) (external). Min. design metal temp. (33) (52) ______ at ______.
9. Impact test ______ (34) [Indicate *yes* or *no* and the component(s) impact tested] at test temperature of ______ (34).
10. Hydro., pneu., or comb. test press. ______ (35) Proof test ______ (36)
11. Nozzles, inspection and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Flange Type	Material		Nozzle Thickness		Reinforcement Material	How Attached		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
				(18)	(18)						
(37)		(38)	(39)	(40)	(41)	(42)		(43)	(44) (45)	(44) (45)	(46)

12. Supports: Skirt ______ (47) (Yes or no) Lugs ______ (47) (No.) Legs ______ (47) (No.) Other ______ (47) (Describe) Attached ______ (47) (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 Commision Number and Endorsement)

(01/12)

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 ______ (1) (Name and address of Manufacturer)
2. Manufactured for ______ (2) (Name and address of Purchaser)
3. Competent Authority ______ (3) (52) (Name of Regulatory Agency and Regulation Met)
4. Type ______ (5) (DOT/UN Spec.) ______ (6) (Manufacturer's Serial No.) ______ (7) (CRN)
   ______ (10) (National Bd. No.) ______ (8) (Drawing No.) ______ (9) (53) (Drawing prepared by) ______ (Year built)
5. ASME Code, Section XII ______ (11) [Edition and Addenda (if applicable) (date)] ______ (12) (Code Case No.) ______ (4) Class ______ (13) (52) Capacity
6. Shell: (a) No. of course(s) ______ (14) (b) Overall length ______ (15)

Course(s)			Material	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat A, B & C)			Heat Treatment	
No.	Diameter	Length	Spec./Grade or Type	Min.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
	(16)	(17)	(18)	(19)	(20)	(21)	(22)		(23)	(24)		(25)	
				(52)									

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.)

	Location (Top, Bottom, Ends)	Thickness		Radius		Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure		Category A		
		Min.	Corr.	Crown	Knuckle					Convex	Concave	Type	Full, Spot, None	Eff.
(a)		(26)	(20)	(27)	(28)								(29)	
(b)			(52)											

If removable, bolts used (describe other fastenings) ______ (30) (Material Spec. No., Grade, Size, No.)

8. MAWP ______ (31) (52) (internal) ______ (external) at max. temp. ______ (32) (internal) ______ (external). Min. design metal temp. ______ (33) (52) at ______.
9. Impact test ______ (34) [indicate *yes* or *no* and the component(s) impact tested] at test temperature of ______ (34).
10. Hydro., pneu., or comb. test press. ______ (35) Proof test ______ (36)
11. Nozzles, inspection and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Flange Type	Material		Nozzle Thickness		Reinforcement Material	How Attached		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
				(18)	(18)						
(37)		(38)	(39)	(40)	(41)	(42)		(43)	(44) (45)	(44) (45)	(46)

12. Supports: Skirt ______ (47) (Yes or no) Lugs ______ (47) (No.) Legs ______ (47) (No.) Others ______ (47) (Describe) Attached ______ (47) (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)

(01/12)

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: *(a)* cylindricals as inside or outside diameter *(b)* transition as inside our outside diameter at the largest and smallest ends *(c)* squares or rectangles as the largest width and height *(d)* 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.

INTENTIONALLY LEFT BLANK

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).

INTENTIONALLY LEFT BLANK

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 CO_2 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 $\frac{1}{2}$ 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.

INTENTIONALLY LEFT BLANK

Case 2708
Use of SA-240/SA-240M UNS S43035 (Grade 439) and UNS S43932 Less Than $^1/_4$ in. (6 mm) in Thickness for the Construction of Water Boilers Intended for Working Pressures Up to 160 psi (1 100 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 $^1/_4$ 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 $^1/_4$ 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 (1 100 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.

INTENTIONALLY LEFT BLANK

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 1548-2008[1] 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.

[1] See 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

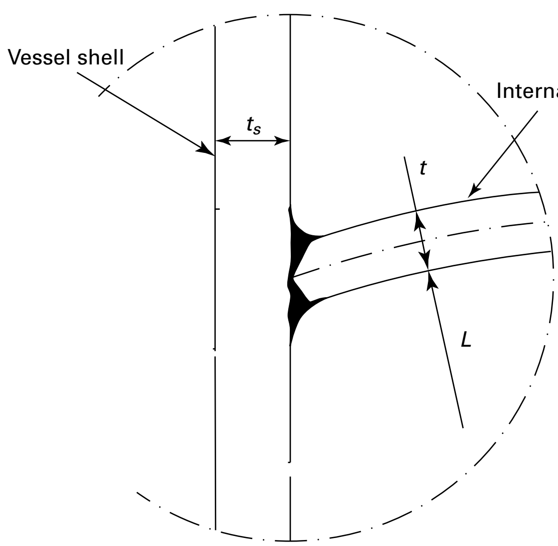
(f) In lieu of the examination described in (e), the weld joint may be examined by liquid penetrant examination in accordance with

(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



INTENTIONALLY LEFT BLANK

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 ft^3 (0.14 m^3).

(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 $2^3/_{16}$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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		
	$t \le 5/16$ in.	$5/16$ in. $< t \le 1/2$ in.	$1/2$ in. $< t \le 3$ 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		
	$t \le 8$ mm	8 mm $< t \le 13$ mm	13 mm $< t \le 75$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $^3/_8$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 D4349-16, 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 D4349-16, 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 lot[1] 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.

[1] The 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 startup 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 batch[2] 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

[2] The 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 batch[2]

(-2) at initial production for each lot[1] 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 strèaks	Dark spots or streaks	None permitted
Blister	Hollows on or in the parts	Pressure side: none permitted; Nonpressure side: maximum diameter, $^1/_{16}$ 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: $^1/_{16}$ in. (1.5 mm), maximum density: 4 per 1 in^2 (4 per 650 mm^2); maximum diameter: $^1/_{16}$ 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 burns 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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

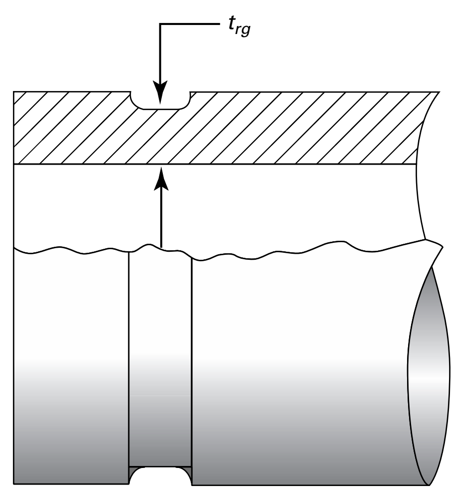
(d) When grooved nozzle ends are used for pipe sizes shown in Table 1, the inside corner radius at the bottom of the groove shall be 0.015 in. (0.381 mm) minimum to 0.030 in. (0.762 mm) maximum.

(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)
$^3/_4$ (20)	0.033 (0.838)
1 (25)	0.044 (1.118)
$1^1/_2$ (40)	0.055 (1.397)
2 (50)	0.055 (1.397)
$2^1/_2$ (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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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

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.

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

INTENTIONALLY LEFT BLANK

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

INTENTIONALLY LEFT BLANK

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 ≤ $^{3}/_{16}$ in. (≤5.0 mm)	101 ksi (700 MPa)	75 ksi (515 MPa)	30%
Plate > $^{3}/_{16}$ 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 ≤$^{3}/_{16}$ in.	Pipe and Tube Wall Thickness >$^{3}/_{16}$ 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 ≤$^3/_{16}$ in.	Pipe and Tube Wall Thickness >$^3/_{16}$ 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.

INTENTIONALLY LEFT BLANK

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/m^3).

(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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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, *t*, in.				
	t ≤ 1.5	1.5 < *t* ≤ 2.5	2.5 < *t* ≤ 4	4 < *t* ≤ 6	6 < *t* ≤ 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, *t*, mm				
	t ≤ 40	40 < *t* ≤ 60	60 < *t* ≤ 100	100 < *t* ≤ 150	150 < *t* ≤ 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, t, in.				
	$t \le 1.5$	$1.5 < t \le 2.5$	$2.5 < t \le 4$	$4 < t \le 6$	$6 < t \le 10$
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, *t*, mm				
	$t \le 40$	$40 < t \le 60$	$60 < t \le 100$	$100 < t \le 150$	$150 < t \le 250$
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, t, in.				
	$t \le 1.5$	$1.5 < t \le 2.5$	$2.5 < t \le 4$	$4 < t \le 6$	$6 < t \le 10$
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, *t*, mm				
	t ≤ 40	40 < *t* ≤ 60	60 < *t* ≤ 100	100 < *t* ≤ 150	150 < *t* ≤ 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.

INTENTIONALLY LEFT BLANK

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.

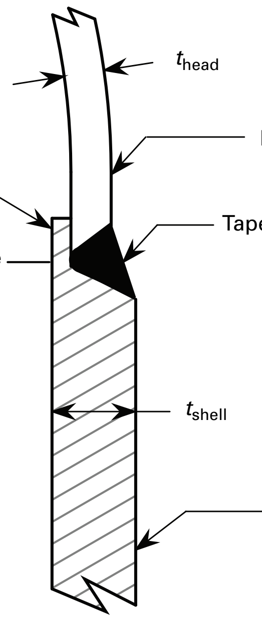
(h) The joint efficiency of the head-to-shell joint shall be 0.90 from Table UW-12 for a Type 2 joint based on full radiographic examination. The limitations in Table UW-12 for the Type 2 joints do not apply.

(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 $3\frac{1}{2}$ 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

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 66⅔% 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 66⅔% 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

INTENTIONALLY LEFT BLANK

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 1 250°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 $3\frac{1}{2}$ 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

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 66⅔% 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.

INTENTIONALLY LEFT BLANK

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 ≤ 7 in. (100 < t ≤ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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, °F	Temperature, °C	Weld Strength Reduction Factor
−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

INTENTIONALLY LEFT BLANK

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 $^{1}/_{32}$ 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.

INTENTIONALLY LEFT BLANK

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 Nonmandatory 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 $^3/_8$ in. (10 mm).

(2) For thicknesses over $^3/_8$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

[1] This 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.

[2] This material may utilize the minimum thickness exceptions of HF-301.1(c) to pressures of 160 psig (1 100 kPa).

[3] Tubing 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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 33⅓% of wall thickness of the finished part or ¾ 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)

INTENTIONALLY LEFT BLANK

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 $^1\!/_4$ 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).

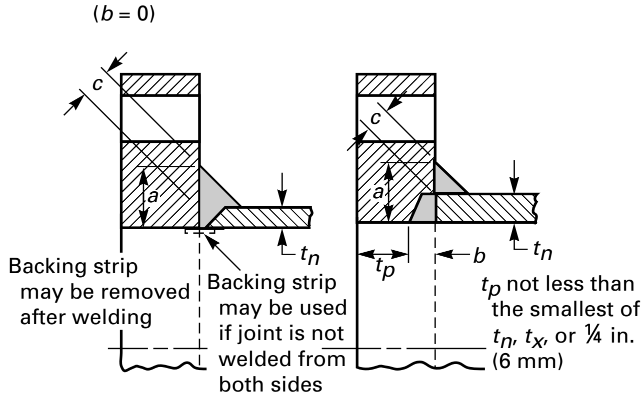
(j) The results of the calculations using the dimensions described in (g), (h), and (i) shall meet all requirements of Section VIII, Division 1, including those in Mandatory Appendix 2, considering all applicable loads.

(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



(m) [Note (1)] **(n) [Note (2)]**

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 $\geq t_n + {}^1\!/_4$ in. (6 mm); c ≥ lesser of $t_{r\ n2}$ or t_x
(2) $a + b \geq 3t_{r\ n2}$ and $\geq t_n + {}^1\!/_4$ in. (6 mm); c ≥ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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	Ø Butt joint	X	...
QW-403	.21	± Coating, plating	X	...
	.22	± T	X	...
QW-407	.1	Ø PWHT	X	...
QW-409	.15(a)(4)	Ø Pressure	X	...
	.15(a)(5)	Ø Current	X	...
	.15(a)(6)	Ø Current time	X	...
	.15(b)	Ø AC to DC	X	...
	.17	Ø Power supply	X	...
	.18	Tip cleaning	...	X
QW-410	.31	Ø Cleaning method	X	...
	.33	Ø Equipment	X	...
	.34	Ø 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.

INTENTIONALLY LEFT BLANK

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/m^3)

(4) modulus of elasticity at 68°F (20°C): 29.7 × 10^6 psi (205 × 10^3 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; ≥ $^7/_{16}$ 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°) 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 $\frac{1}{2}$ 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 reaustenitized 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 reaustenitized 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 reaustenitized 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} (7 810kg/m^3). 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.

INTENTIONALLY LEFT BLANK

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°F ± 25°F (600°C ± 15°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} (8 520 kg/m^3)

(2) thermal conductivity

(-a) 212°F (100°C): 44 Btu/(h·ft·°F) (77 W/m·K)

(-b) 572°F (300°C): 59.5 Btu/(h·ft·°F) (103 W/m·K)

(3) Coefficient of thermal expansion, 10^{-6}/°F: 11 (10^{-6}/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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 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.

INTENTIONALLY LEFT BLANK

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 (1 290)

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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/m^3).

(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 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 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

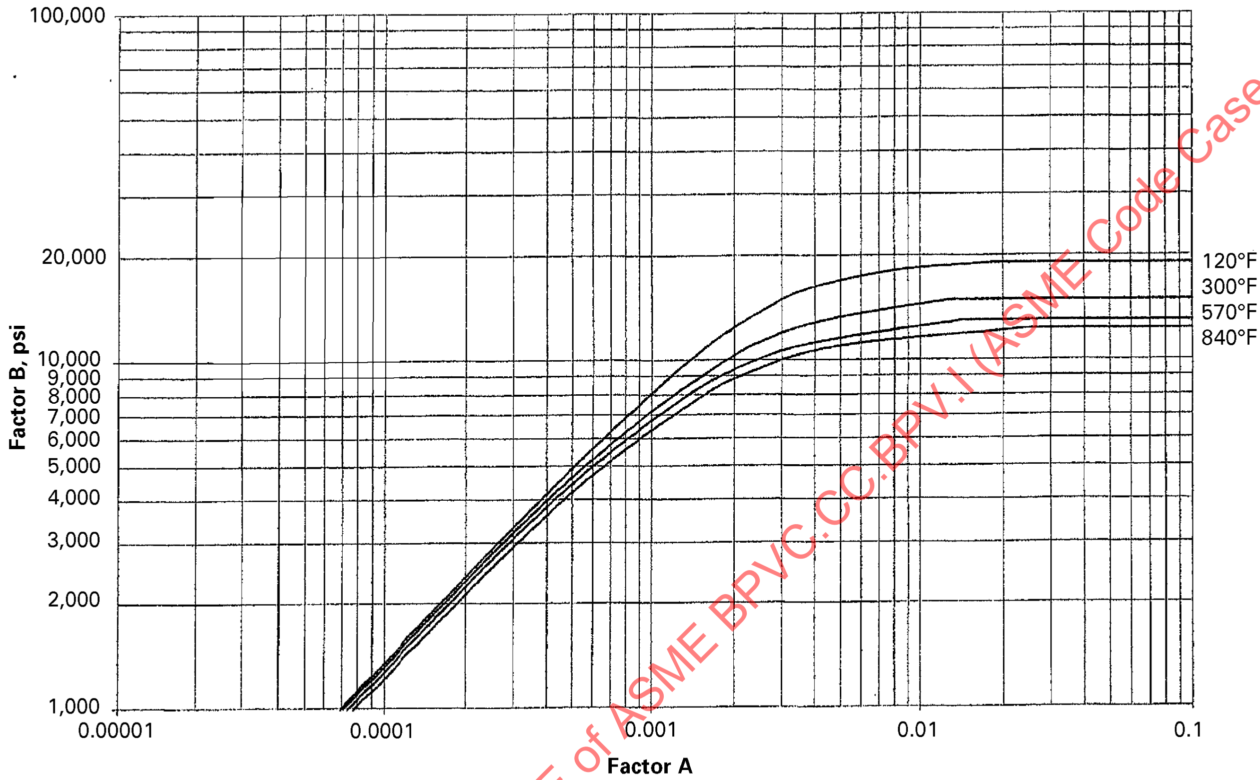
NOTES:
(1) Section II, Part D, Subpart 1, Table Y-1, Note (b) applies to these values.
(2) Section II, Part D, Subpart 1, Table U, Note (b) applies to these values.

Table 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.

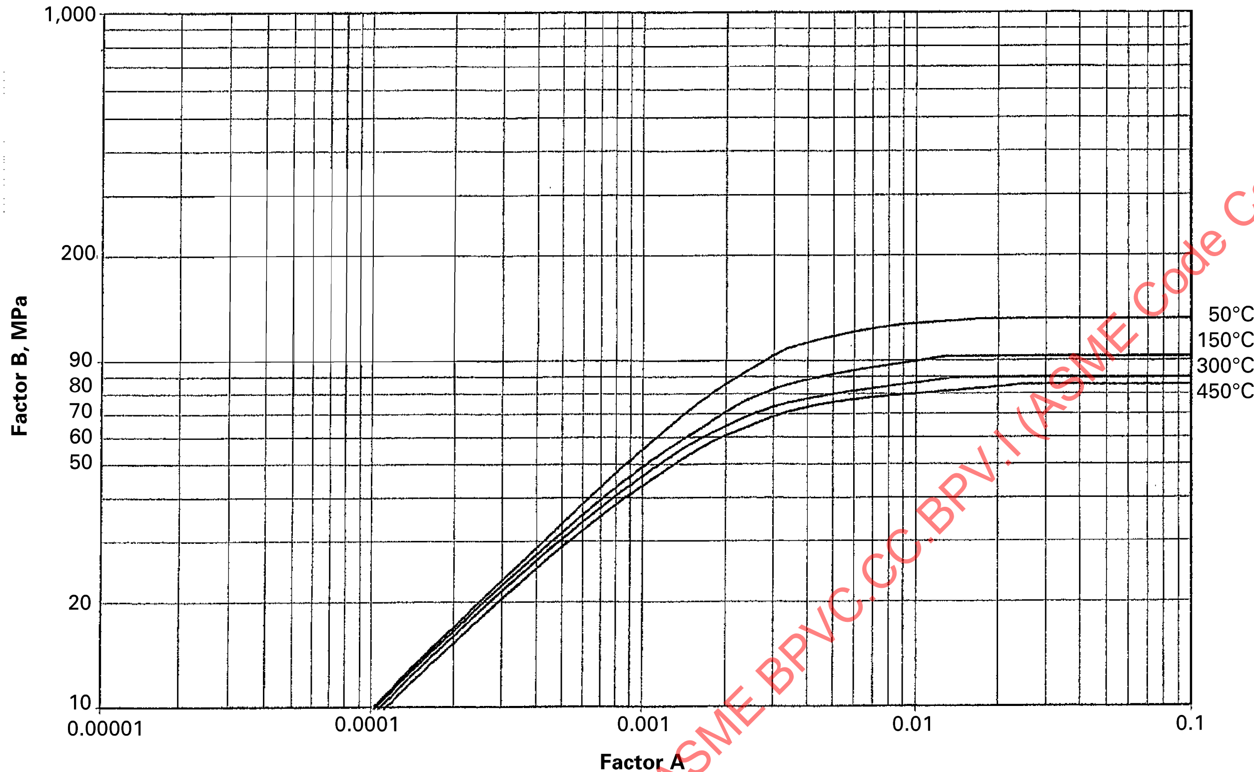
Figure 1
External Pressure Chart for UNS N06845



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 ±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 $^2/_3$ 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°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 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. ± $^1/_{16}$ 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 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. ± $^1/_{16}$ 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 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.

$$S_h = Pr/t \tag{1}$$

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:

$$S_{lp} = Pr/2t \tag{2}$$

where

S_{lp} = longitudinal stress value at pressure P

$$S_l = S_{lp} + W/A \tag{3}$$

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)	...

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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)	ø ±10 deg	X	...	...
	.12(b)	ø Cross-section > 10%	X	...	...
	.12(c)	ø O.D. > ±10%	X	...	...
QW-403, Base Metals	.24	ø Specification, type, or grade	X	...	...
QW-406, Preheat	.7	ø > 10% Amperage or number of preheat cycles or method, or > 25°F temperature	X	...	...
QW-407, PWHT	.8	ø PWHT, PWHT cycles, or separate PWHT time or temperature	X	...	...
QW-408, Gas	.22	ø Shielding gas composition, pressure, or purge time	X	...	...
QW-410, Technique	.17	ø Type/model of equipment	X	...	...
	.27	ø Spp. > ±10%	X	...	...
	.31	ø Cleaning method	X	...	...
	.54	ø > 10% Upset length or force	X	...	...
	.55	ø > 10% Distance between clamping dies or preparation of clamping area	X	...	...
	.57	ø > 10% Forward or reverse speed	X	...	...

Legend:
Ø = 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 3463:2006[1] 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.

INTENTIONALLY LEFT BLANK

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 3463:2006[1] 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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												
°F	°C	N06045	N06600	N06690	N06601	N06025	N10276	N06022	N06230	N06625	N06617 (Except SAW) [Note (1)]	N06617 (SAW) [Note (2)]	N07740	Autogenous Welded Nickel Base Alloys
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.

INTENTIONALLY LEFT BLANK

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 $^3\!/_4$ 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 $^1\!/_2$ in. (13.0 mm).

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

INTENTIONALLY LEFT BLANK

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 $^3/_{16}$ 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 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.

INTENTIONALLY LEFT BLANK

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 $^3\!/_{16}$ 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 $^3\!/_{16}$ 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 $^3/_{16}$ 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 $66^2/_3$%, 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 $66^2/_3$%, 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 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 66⅔%, 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 66⅔%, 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.

INTENTIONALLY LEFT BLANK

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)

INTENTIONALLY LEFT BLANK

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 requalification 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.

INTENTIONALLY LEFT BLANK

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 $^5/_{32}$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

Case 2816
Use of Ultrasonic Examination in Lieu of Radiography for Material Thickness Less Than ½ in. (13 mm) But Greater Than or Equal to ¼ 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 ½ in. (13 mm) but thicker than or equal to ¼ 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 ¼ in. to ½ 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 ¼ 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 ¼ 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 counterbore; 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)	≤$\frac{1}{4}$ (≤6.4)
$\frac{3}{8}$ (10)	0.042 (1.04)	0.021 (0.52)	≤$\frac{1}{4}$ (≤6.4)
<$\frac{1}{2}$ (<13)	0.044 (1.13)	0.022 (0.57)	≤$\frac{1}{4}$ (≤6.4)

GENERAL NOTES:

(a) 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.

(b) 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.

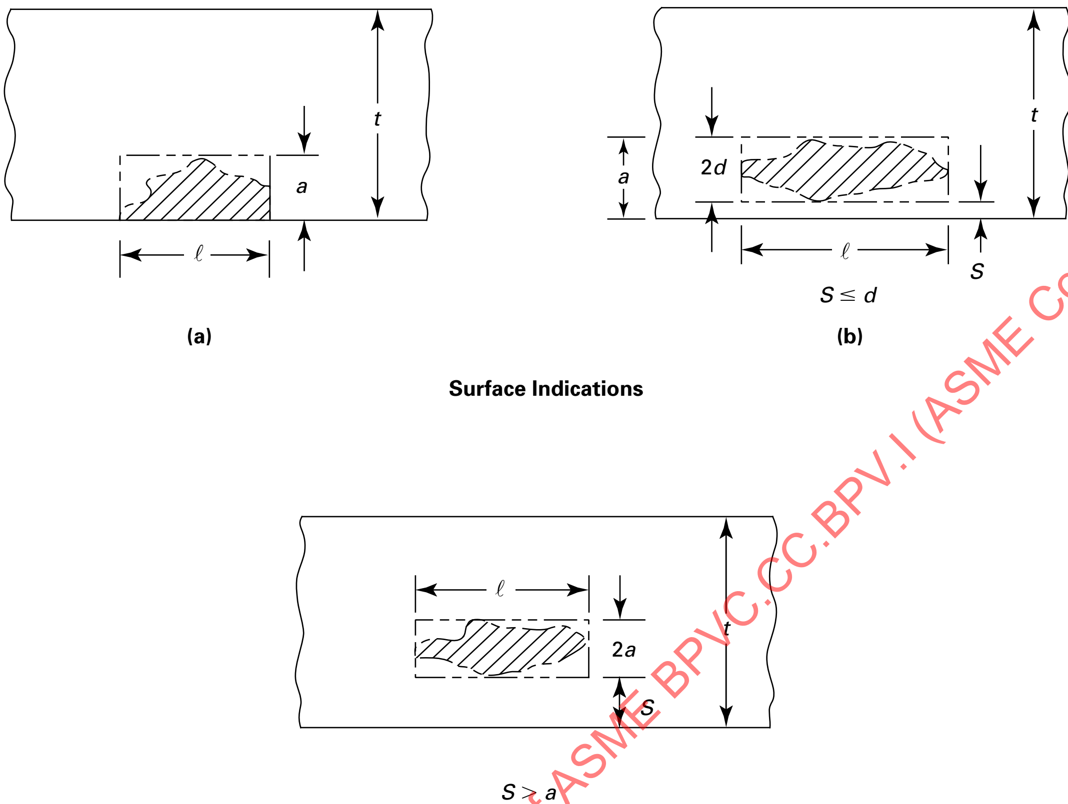
(c) Parameters a and ℓ are as defined in (i)(3)(-a) and (i)(3)(-b).

(d) For intermediate thicknesses of t [$\frac{1}{4}$ in. (6 mm) < t <$\frac{1}{2}$ in. (13 mm)], linear interpolation is permissible.

(e) 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.

(f) 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



(c) Subsurface Indications

Figure 2
Multiple Planar Flaws Oriented in Plane Normal to Pressure Retaining Surface

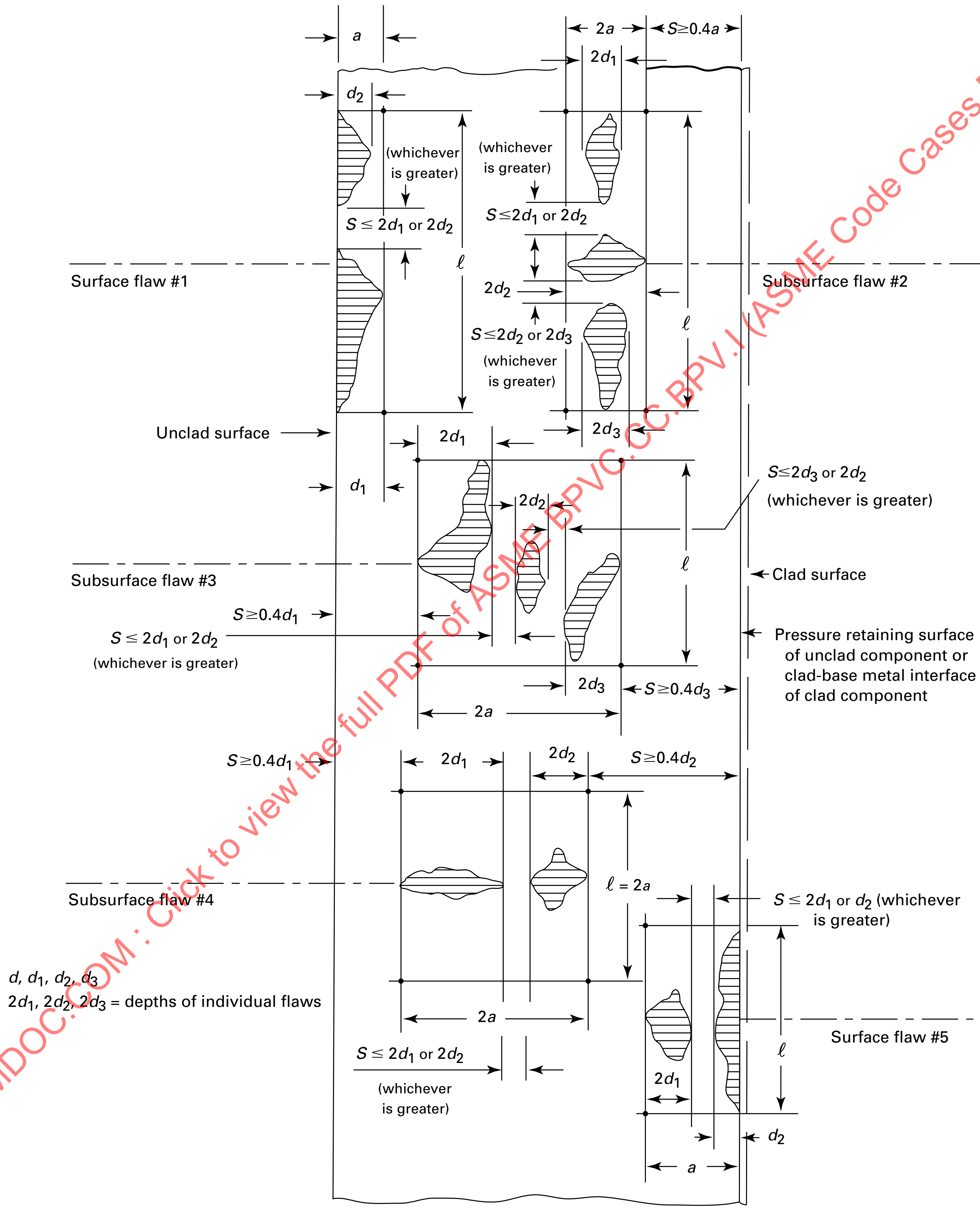


Figure 3
Flaws Oriented Primarily in Parallel Planes

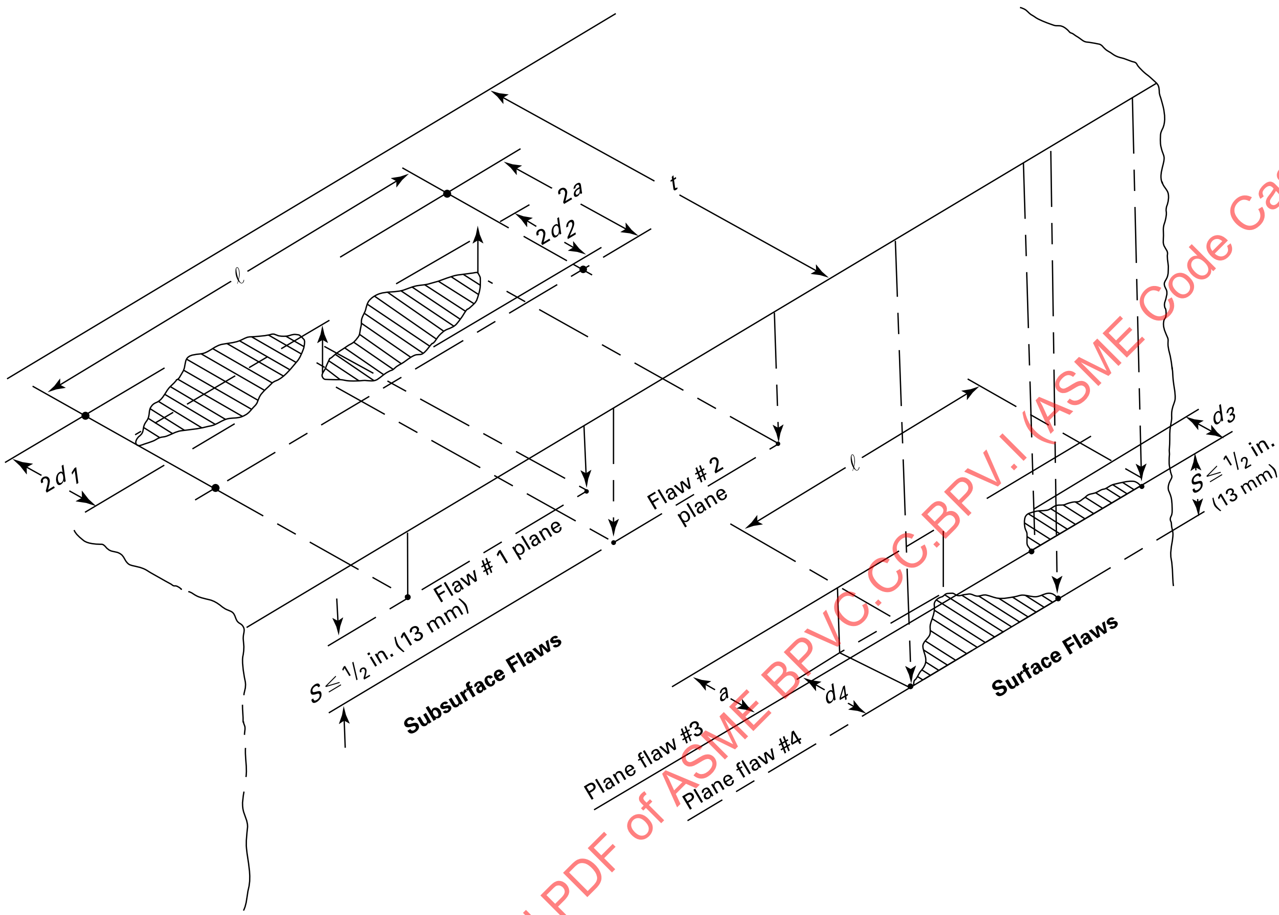


Figure 4
Nonaligned Coplanar Flaws in Plane Normal to Pressure Retaining Surface (Illustrative Flaw Configurations)

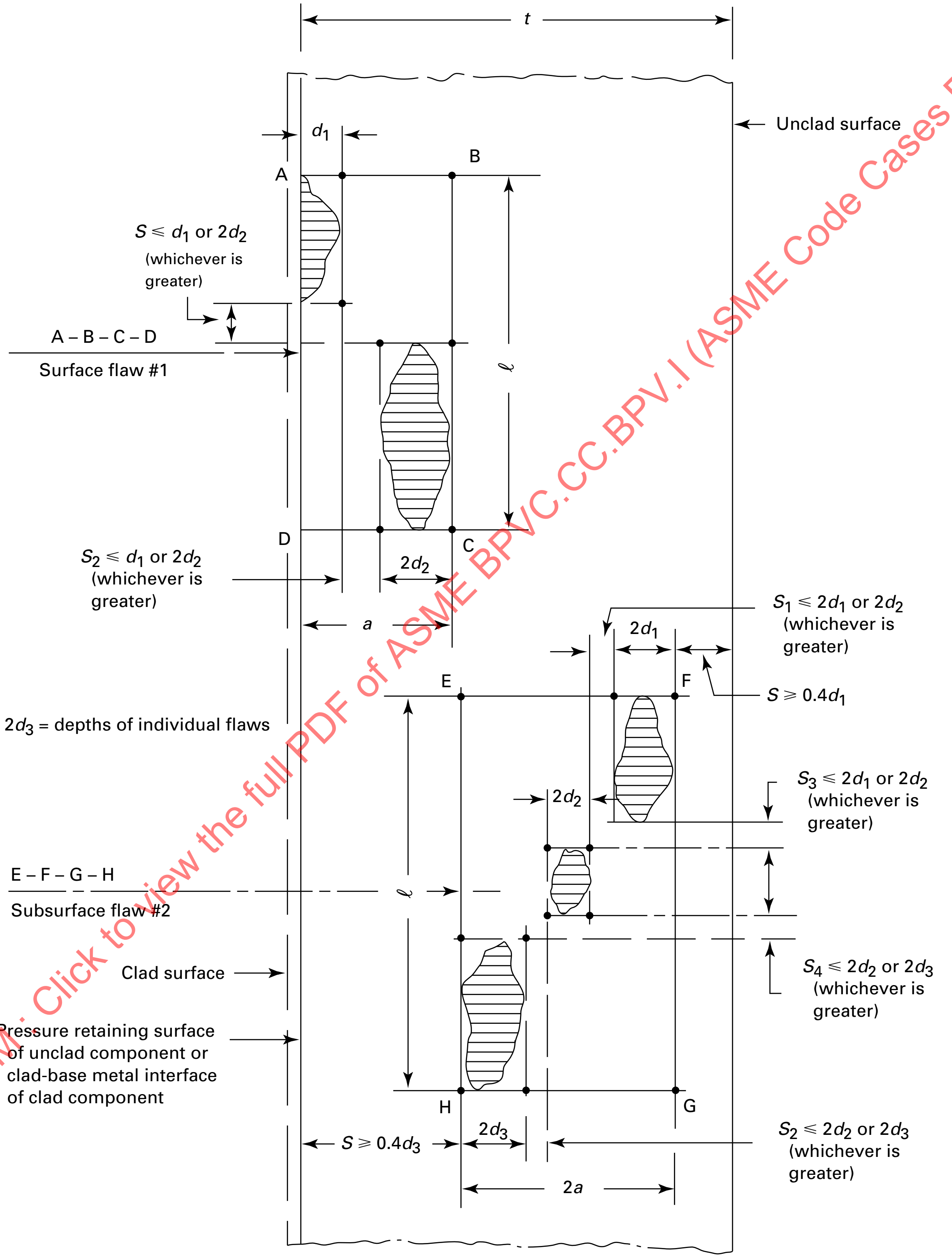
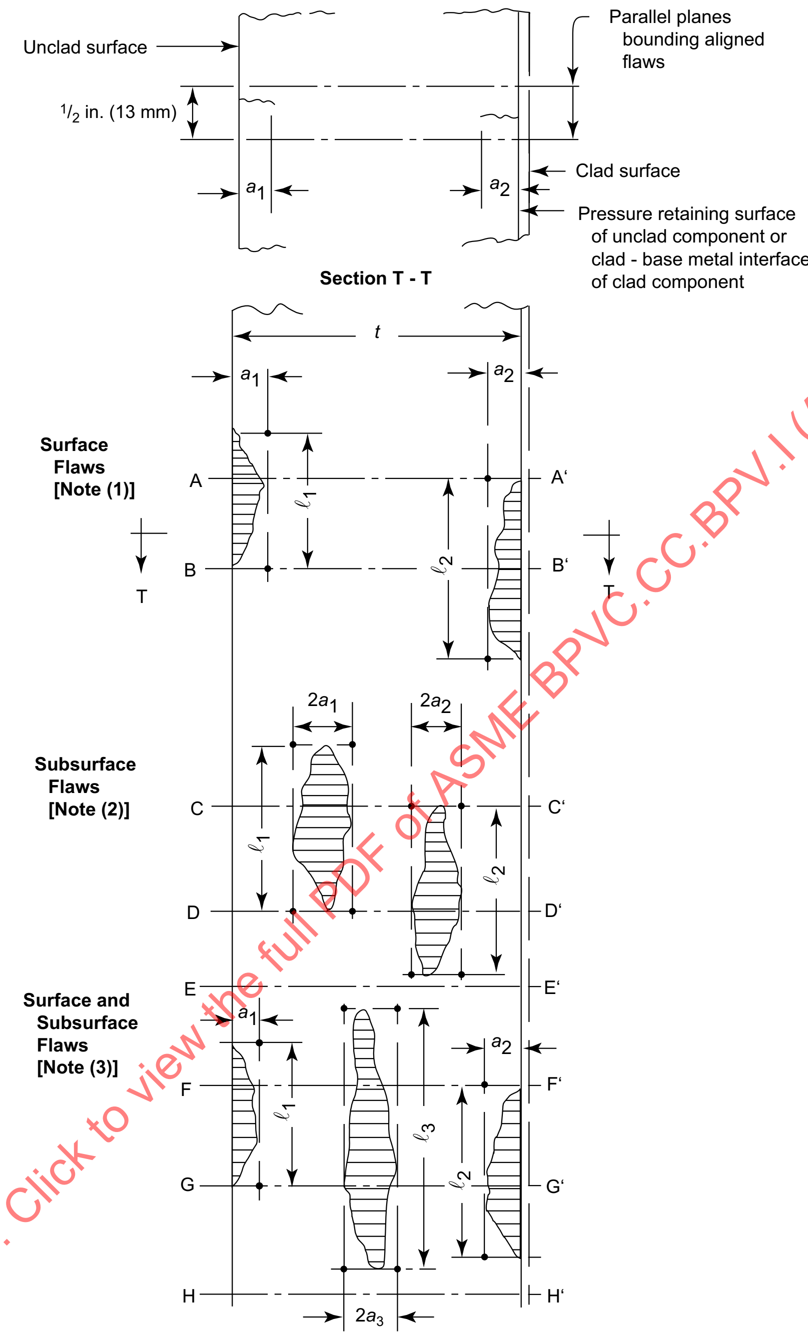


Figure 5
Multiple Aligned Planar Flaws



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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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)

$$\dot{\varepsilon} \leq \frac{3(10)^{-8}}{\text{hr}} \tag{1}$$

(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:

$$P_L + P_b + Q + F \leq \left(S_h + S_{yc}\right) \quad (2)$$

(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.

$$\dot{\varepsilon}_c = \frac{\dot{\varepsilon}_{oc}}{1 - D_c} \quad (3)$$

$$\log_{10} \quad \dot{\varepsilon}_{oc} = -\left\{A_0 + \left(\frac{A_1 + A_2S_l + A_3S_l^2 + A_4S_l^3}{T}\right)\right\} \quad (4)$$

$$S_l = \log_{10}(\sigma_e) \quad (5)$$

$$\sigma_e = \frac{1}{\sqrt{2}}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2\right]^{0.5} \quad (6)$$

$$D_c = \int_0^t \dot{D}_c dt \leq 1.0 \quad (7)$$

$$\dot{D}_c = \Omega_m \dot{\varepsilon}_{oc} \quad (8)$$

$$\Omega_m = \Omega_n^{\delta+1} \quad (9)$$

$$\Omega_n = \text{max.}\ [(\Omega - n), 3.0] \quad (10)$$

$$\log_{10} \quad \Omega = B_0 + \left(\frac{B_1 + B_2S_l + B_3S_l^2 + B_4S_l^3}{T}\right) \quad (11)$$

$$n = -\left(\frac{A_2 + 2A_3S_l + 3A_4S_l^2}{T}\right) \quad (12)$$

$$\delta = \beta\left(\frac{3p}{\sigma_e} - 1.0\right) \quad (13)$$

$$p = \frac{\sigma_1 + \sigma_2 + \sigma_3}{3} \quad (14)$$

(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.

$$L_{cwf} = L_{caf} \cdot \left(\frac{\beta_{cf} \cdot \Delta\varepsilon_{peq} \cdot N}{\exp\left[\beta_{cf} \cdot \Delta\varepsilon_{peq} \cdot N\right] - 1} \right), \quad \Delta\varepsilon_{peq} > 0 \qquad (15)$$

$$L_{cwf} = L_{caf}, \quad \Delta\varepsilon_{peq} = 0 \qquad (16)$$

(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.

$$L_{cwf} = L_{caf} \cdot \left[\frac{\beta_{cf} \cdot \sum_{i=1}^{k} \Delta\varepsilon_{peq,k}}{\exp\left[\beta_{cf} \cdot \sum_{i=1}^{k} \Delta\varepsilon_{peq,k}\right] - 1} \right], \quad \Delta\varepsilon_{peq} > 0 \qquad (17)$$

$$L_{cwf} = L_{caf}, \quad \Delta\varepsilon_{peq} = 0 \qquad (18)$$

(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 $^1/_3$

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, $\dot{\varepsilon}_0$ [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, $\dot{\varepsilon}_0$, 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, $\dot{\varepsilon}_0$ [Note (1)]		Omega Parameter, Ω [Note (1)]	
9Cr-1Mo-V	A_0	−34	B_0	−2
	A_1	40 290.39	B_1	4 698.864
	A_2	2 182.414	B_2	−833.333
	A_3	−1 800.8	B_3	0
	A_4	−316.111	B_4	0

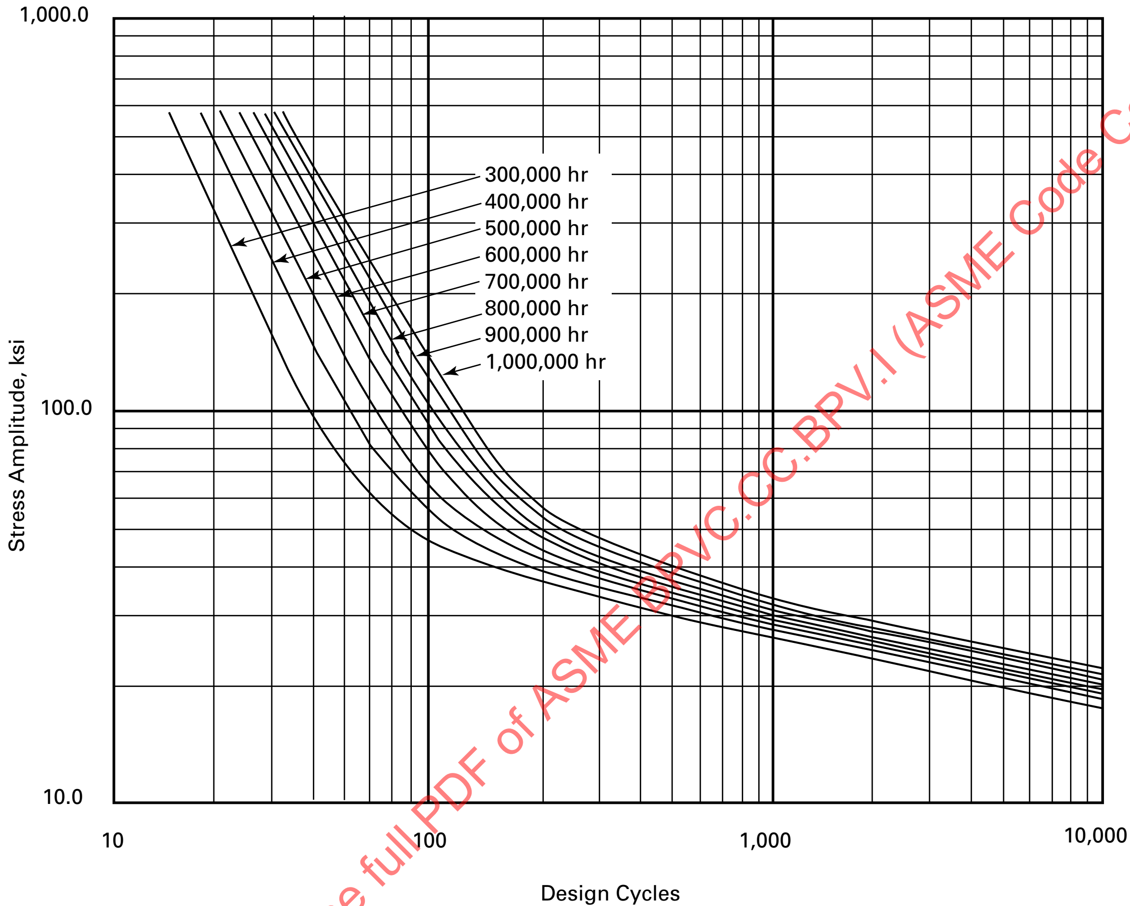
GENERAL NOTE: The coefficients in this table represent minimum material behavior.

NOTE: (1) The units of measure for computing the strain rate parameter, $\dot{\varepsilon}_0$, and the Omega parameter, Ω, using the coefficients in this table are MPa and °K.

Table 2
Total Accumulated Inelastic Strain

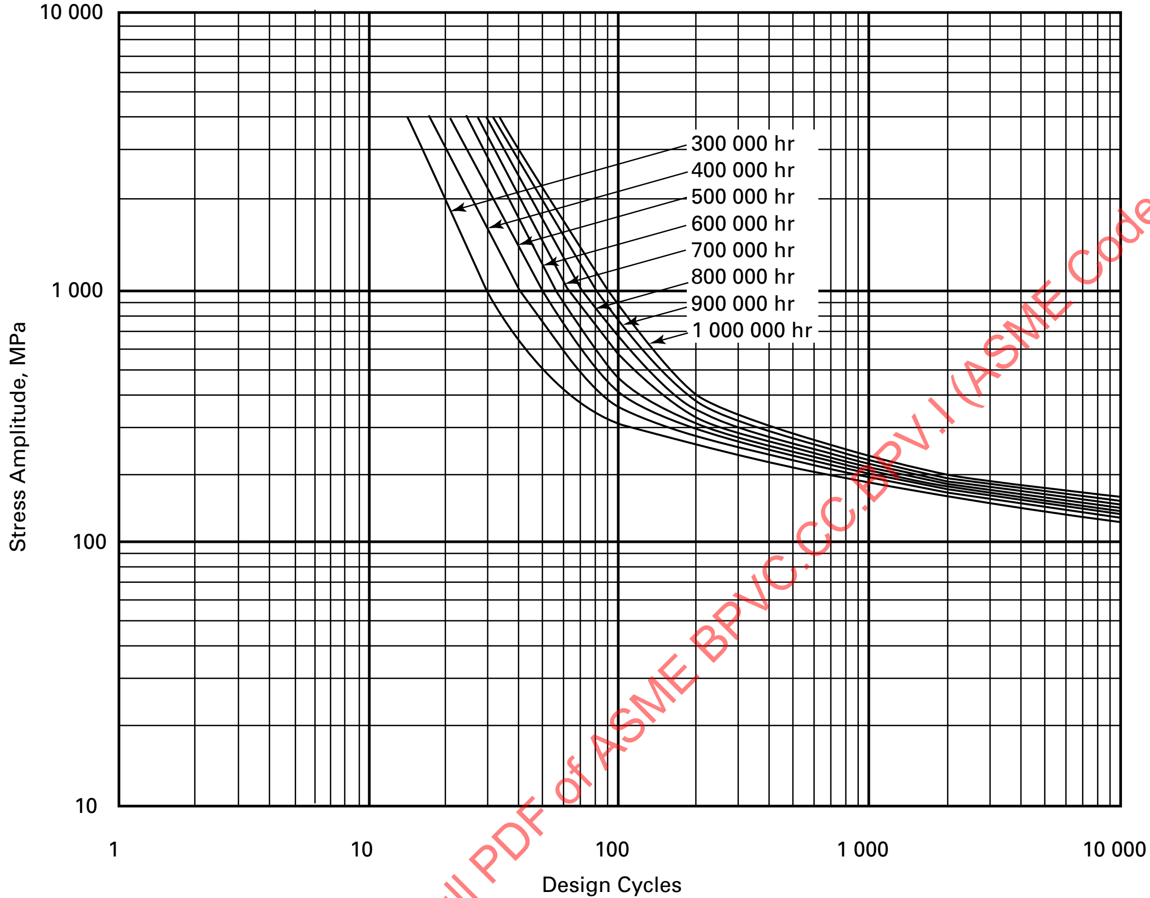
Type of Stress	Equivalent Total Accumulated Inelastic Strain	
	Weld and HAZ	Other Parts
Membrane	0.5%	1.0%
Membrane plus bending	1.25%	2.5%
Local (at any point)	2.5%	5.0%

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	2 024	2 698	3 373	4 047	4 722	5 396	6 070	6 745
159	2 237	2 983	3 729	4 474	5 220	5 966	6 711	7 457
156	2 473	3 298	4 122	4 947	5 771	6 596	7 420	8 244
153	2 735	3 646	4 558	5 469	6 381	7 292	8 204	9 115
150	3 023	4 031	5 039	6 047	7 054	8 062	9 070	10 078
148	3 343	4 457	5 571	6 685	7 799	8 913	10 028	11 142
145	3 696	4 927	6 159	7 391	8 623	9 855	11 086	12 318
142	4 086	5 448	6 809	8 171	9 533	10 895	12 257	13 619
140	4 517	6 023	7 528	9 034	10 540	12 045	13 551	15 057
137	4 994	6 659	8 323	9 988	11 652	13 317	14 982	16 646
135	5 521	7 362	9 202	11 042	12 883	14 723	16 564	18 404
132	6 104	8 139	10 174	12 208	14 243	16 278	18 312	20 347
130	6 749	8 998	11 248	13 497	15 747	17 996	20 246	22 495
127	7 461	9 948	12 435	14 922	17 409	19 896	22 383	24 870
125	8 249	10 998	13 748	16 498	19 247	21 997	24 747	27 496
123	9 120	12 160	15 200	18 240	21 279	24 319	27 359	30 399
120	10 083	13 443	16 804	20 165	23 526	26 887	30 248	33 609
118	11 147	14 863	18 579	22 294	26 010	29 726	33 441	37 157
116	12 324	16 432	20 540	24 648	28 756	32 864	36 972	41 080
114	13 625	18 167	22 709	27 250	31 792	36 334	40 875	45 417
112	15 064	20 085	25 106	30 127	35 149	40 170	45 191	50 212
110	16 654	22 205	27 757	33 308	38 860	44 411	49 962	55 514
108	18 412	24 550	30 687	36 825	42 962	49 100	55 237	61 375
106	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 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	3 982	0.02000000
440.7	3 039	0.01480000
339.2	2 339	0.01095200
263.9	1 820	0.00810400
207.9	1 434	0.00599700
166.3	1 147	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.

INTENTIONALLY LEFT BLANK

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 (1 100 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 ft^3 (0.028 m^3), 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 $\frac{1}{2}$ 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.

INTENTIONALLY LEFT BLANK

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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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/m^3), 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_a, 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_a, 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_a, 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 66⅔% 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_a, 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 66⅔% 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 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 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

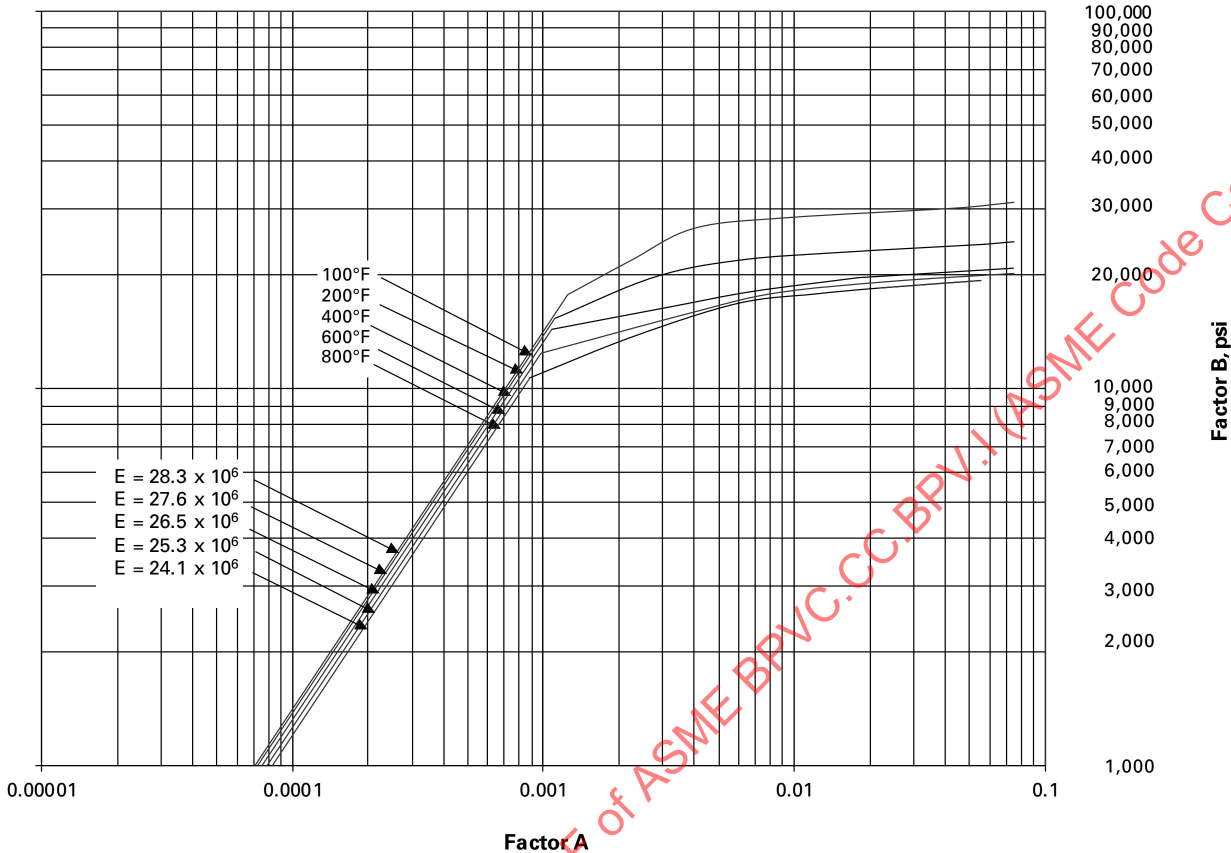
Table 8
Tabular Values for Figure 1

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)

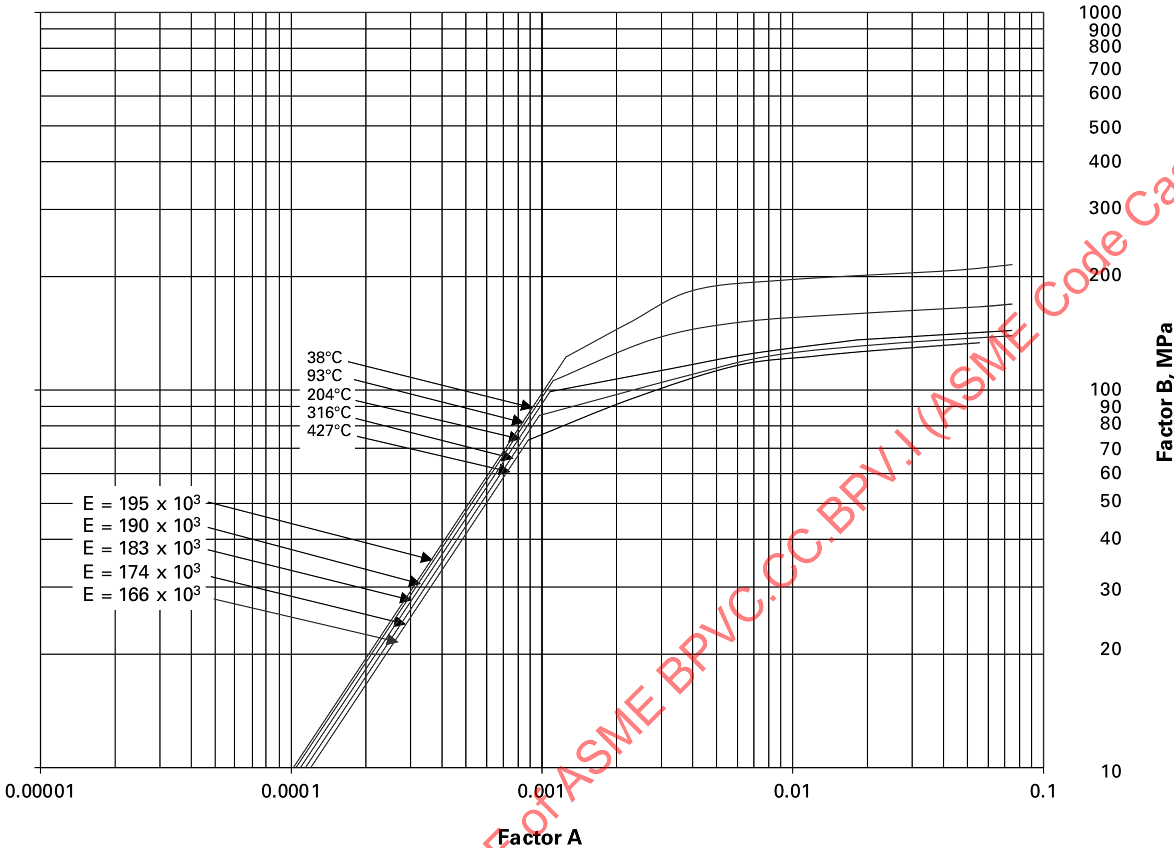


GENERAL NOTES:

(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.

INTENTIONALLY LEFT BLANK

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 form 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 $^1/_8$ 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 > ±10% [Note (1)]			X
	.X(b)	φ Hole base diameter ±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	± 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 ±10% (see Figure QW-461.XX)
(2) A change in the hole base diameter greater than ±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 ±5%
(b) rotational rpm greater than ±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

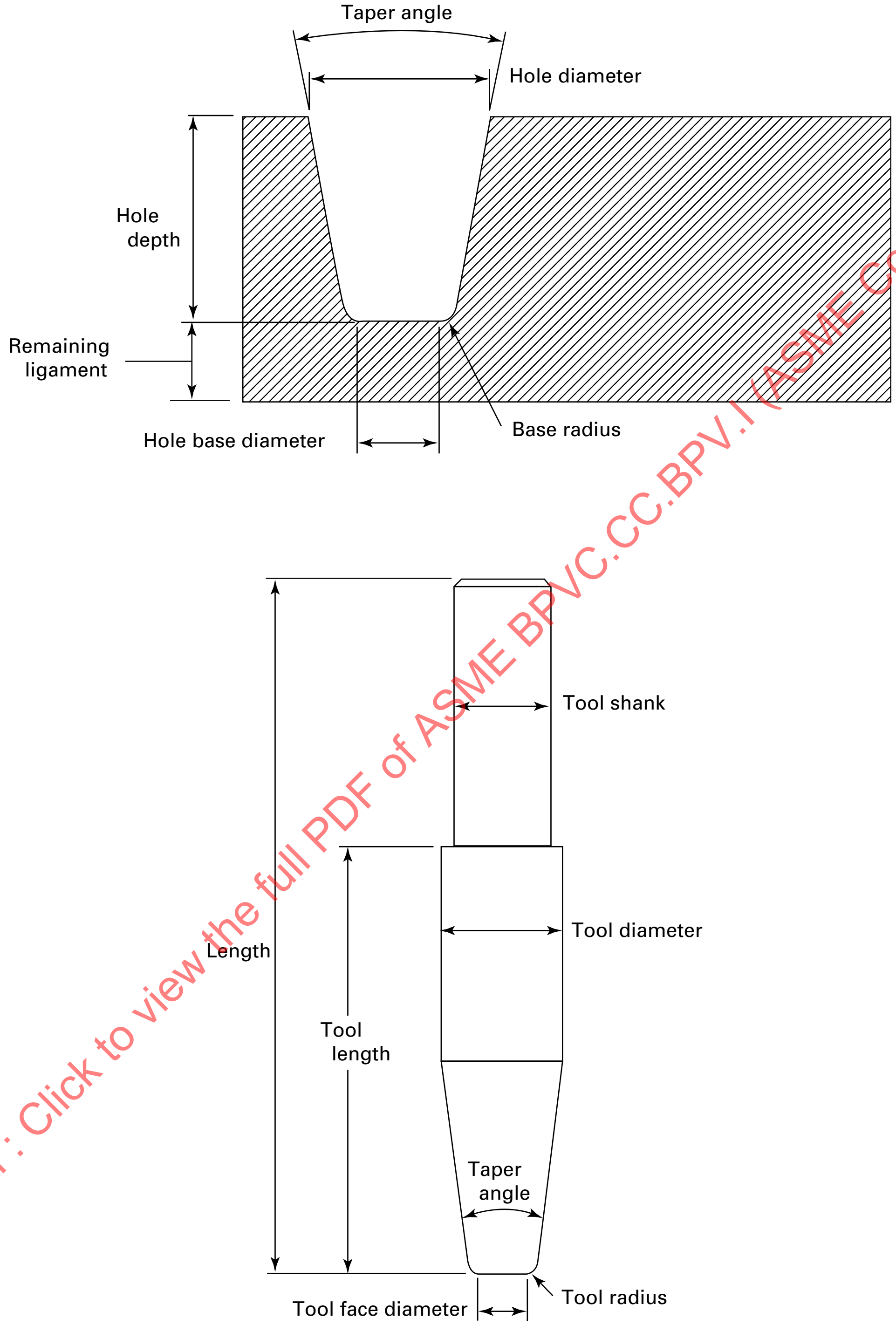


Figure 2
Tensile Test Specimen Removal

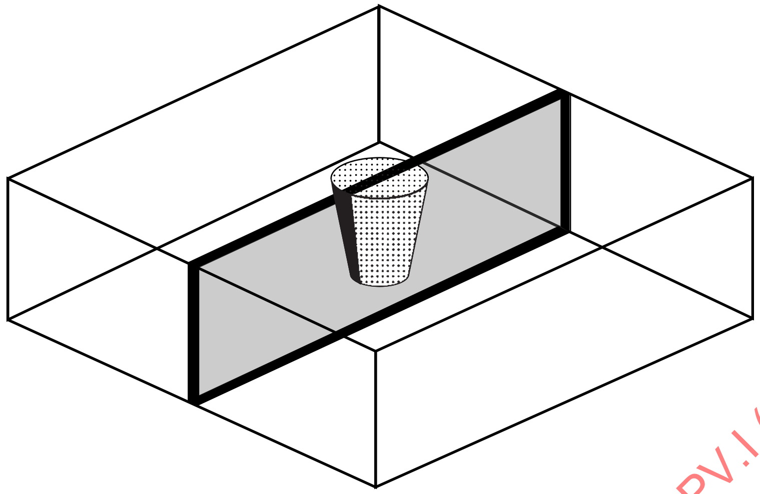
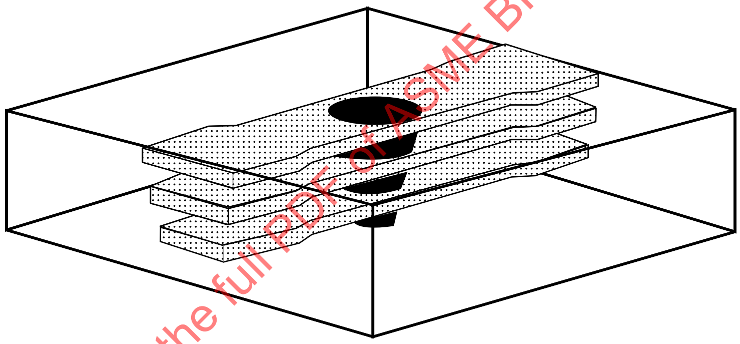


Figure 3
Bend Test Specimen Removal



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.

INTENTIONALLY LEFT BLANK

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

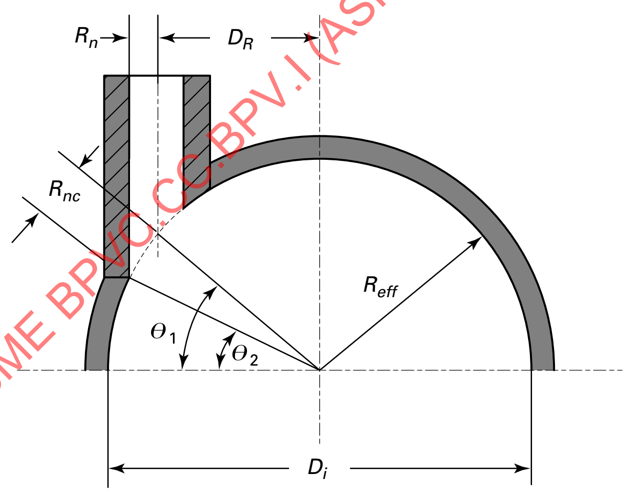
R_{eff} = effective pressure radius

= $0.5D_i$

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



INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 ±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 ±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)] ______________________

*ShellSize 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 ______ (1) ______
(name and address of Manufacturer)

2. Manufactured for ______ (2) ______
(name and address of purchaser)
______

3. Operating location ______ (3) ______
(where installed and where transported)

4. Type ______ (4) ______ (horizontal/vertical) ______ (5) ______ (Manufacturer's serial no.) ___ (6) ___ (CRN) ______ (7) ______ (National Board No.) ______ (year built)

Drawing no. ______ (8) ______ Prepared by ______ (9) ______

5. User's Design Specification on file at ______ (10) ______

Certified by ______ (10) ______ P.E. state ___ (11) ___ Reg. no. ______

6. Manufacturer's Design Report on file at ______ (10) ______

Certified by ______ (10) ______ P.E. state ___ (11) ___ Reg. no. ______

6a. Wire Winding Procedure Specification on file at ______ (10) ______

Qualification Report No. ______ Dated ______ , ______ Latest requalification date ______ , ______

7. Material ______ (12) ______ Impact tested at ______ °F

8. ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 3 ___ (13) ___ (year) ______ (14) ______ (Code Case no.)

9. Service ______ (15) ______

10. Restrictions and warnings ______ (16) (17) ______

___ (18) ___ cycles at ______ psig at ______ °F ______

11. Construction ______ (19) (20) (21) ______

Prestress method ______ (22) ______

12. Size and configuration ______ (23) ______ (I.D.) ______ (24) ______ (length) ______ (25) ______ (thickness) ______ (cylindrical, spherical, other)
______

13. Supports and attachments ______ (26) ______

14. Design pressure ___ (27) ___ psi at maximum coincident metal temperature ______ (28) ______ °F

Service pressure ______ (29) ______ at vessel/contents temperature of 70°F (20°C)

Maximum metal vessel temperature ______ (28) ______ °F at ______ (28) ______ psi

Minimum design metal vessel temperature ______ (30) ______ °F at ______ (30) ______ psi

15. Test pressure ______ (31) ______ psi ______ (31) ______ (pneum./hydro./combination) at ______ (31) ______ °F

Performed in the ______ (31) ______ (horiz./vertical) position ______ [fluid(s) used in test]

16. Closures ______ (32) ______
(describe)

17. Connections, or provisions, for overpressure relief ______ (33) ______

(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)	(25)			(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.]

(2/16)

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: 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.

INTENTIONALLY LEFT BLANK

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 ±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. ±$^1/_{16}$ 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. ±$^1/_{16}$ 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 to149°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)	...

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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} (7 900 kg/m^3)

(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. % [Note (1)]	19

NOTE:
(1) 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, in.	Elongation in 2 in., Min. %
$^5/_{16}$ (0.312)	19.0
$^9/_{32}$ (0.281)	18.0
$^1/_4$ (0.250)	17.0
$^7/_{32}$ (0.219)	16.0
$^3/_{16}$ (0.188)	15.0
$^5/_{32}$ (0.156)	14.0
$^1/_8$ (0.125)	13.0
$^3/_{32}$ (0.094)	12.0
$^1/_{16}$ (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 $^1/_{32}$ 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.

INTENTIONALLY LEFT BLANK

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 (1 010°C to 1 150°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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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:

$$P_m \leq S \tag{1}$$

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 1.5S:

$$P_L + P_b \leq 1.5S \tag{2}$$

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}:

$$P_m \leq S_{mt} \tag{3}$$

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:

$$(P_L + P_b) \leq KS_m \tag{4}$$

$$(P_L + P_b/K_t) \leq S_t \tag{5}$$

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.

$$\sum_i \left(\frac{t_i}{t_{im}}\right) \leq 1.0 \tag{6}$$

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.

$$\sum_i \left(\frac{t_i}{t_{ib}}\right) \leq 1.0 \tag{7}$$

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:

$$\sum_i \left(\frac{t_i}{r\, t_{id}} \right) \leq 0.1 \tag{8}$$

(b) Equation (9) as follows:

$$\sum \varepsilon_i \leq 0.2\% \tag{9}$$

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:

$$(P_L + P_b + Q) \leq \text{lesser of}\,(3S_m \text{ or } 3\overline{S}_m) \tag{10}$$

The value of S_m is determined at the maximum wall temperature at the high end of the cycle. The value of $3\overline{S}_m$ is determined from the following:

(1) when part of the cycle falls below the creep temperature given in Table 7

$$3\overline{S}_m = 1.5S_{mL} + 0.5S_{tH}$$

(2) when both temperature extremes of the cycle are above the temperature shown in Table 7

$$3\overline{S}_m = 0.5S_{tL} + 0.5S_{tH}$$

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 $3\overline{S}_m$ 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 $0 < x < 0.5$

$$y' = \frac{1}{x} \tag{11}$$

(-b) for $0.5 < x < 1.0$

$$y' = 4(1 - x) \tag{12}$$

(2) for parabolic thermal distribution

(-a) for $0.3 < x < 0.615$

$$y' = 10.3855e^{-2.6785x} \tag{13}$$

(-b) for $0.615 < x < 1.0$

$$y' = 5.2(1 - x) \tag{14}$$

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.

$$X = \frac{(P_L + P_b/K_t)_{\max}}{S_{ya}} \tag{15}$$

$$Y = \frac{Q_{\text{range}}}{S_{ya}} \tag{16}$$

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:

$$\left(X + Y \right) \leq \frac{S_a}{S_{ya}} \tag{17}$$

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:

$$X + Y \leq 1 \tag{18}$$

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

$$X_1 = \frac{(P_{1L} + P_{1b}/K_t)_{max}}{S_{yL}} \tag{19}$$

(3) The quantity Y_1 in Figures 8 and 9 is given by

$$Y_1 = \frac{Q_1}{S_{yL}} \tag{20}$$

(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.

$$\sigma_c = Z \times S_{yL} \tag{21}$$

(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

$$\varepsilon_e = \frac{1.25\sigma_c}{E} \tag{22}$$

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 $\varepsilon_i = \varepsilon_{cr} - \varepsilon_e$

(10) The inelastic creep strain ε_i, is limited to 1% for parent metal and ½% 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

$$Z = X \tag{23}$$

(2) Regime S_1

$$Z = Y + 1 - 2\sqrt{(1 - X)Y} \tag{24}$$

(3) Regimes S_2 and P

$$Z = XY \tag{25}$$

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 ≤1%

(b) strains at the surface due to an equivalent linear distribution of strain through the thickness ≤2%

(c) local strains at any point ≤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 $(P_L + P_b + Q) \le 3S$ 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

$$\Delta\varepsilon_{\max} = \frac{2S_{alt}}{E} \tag{26}$$

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 modified maximum equivalent strain range, $\Delta\varepsilon_{\text{mod}}$, relative to the maximum equivalent strain range, $\Delta\varepsilon_{\max}$, is given by

$$\Delta\varepsilon_{\text{mod}} = \frac{S^*}{\bar{S}} \times K_S^2 \times \Delta\varepsilon_{\max} \tag{27}$$

(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:

$$\Delta\varepsilon_{\text{mod}} = K_S^2 \times S^* \times \frac{\Delta\varepsilon_{\max}}{\Delta\sigma_{\text{mod}}} \tag{28}$$

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

$$\Delta\varepsilon_{\text{mod}} = K_e \times K_S \times \Delta\varepsilon_{\max} \tag{29}$$

where

$$K_e = 1.0 \text{ if } K_s \times \Delta\varepsilon_{\max} \le \frac{3\bar{S}}{E}$$
$$= K_s \times \Delta\varepsilon_{\max} \times \frac{E}{3\bar{S}} \text{ if } K_s \times \Delta\varepsilon_{\max} > \frac{3\bar{S}}{E}$$

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_ν, defined as

$$K_\nu = 1.0 + f(K'_\nu - 1.0) \tag{30}$$

where

f = the triaxiality factor
K'_ν = 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.

$$\Sigma\left(\frac{\Delta t}{T_d}\right)_k \quad (32)$$

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.

$$\Sigma\left(\frac{n_c}{N_d}\right)_j \leq 1.0 \quad (33)$$

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:

$$\Sigma\left(\frac{\Delta t}{T_d}\right)_k + \Sigma\left(\frac{n_c}{N_d}\right)_j \leq D \quad (34)$$

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

$\Delta\varepsilon_{\max}$ = the maximum equivalent strain range as obtained from eq. (31)

$\Delta\varepsilon_{\text{mod}}$ = the modified maximum equivalent stain 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 $1.25S_y$ 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 $\Delta\varepsilon_{\max}$

$\bar{S}$ = 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 $K\Delta\varepsilon_{\max}$

$2S_{alt}$ = $(P_L + P_b + Q)$ 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:

(a) 100% of the average stress required to obtain a total (elastic, plastic, primary, and secondary creep) strain of 1%

(b) 80% of the minimum stress to cause initiation of tertiary creep

(c) 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- 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_t, 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
2¼Cr-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 2¼ 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
2¼Cr-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 $S = S_t$ 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

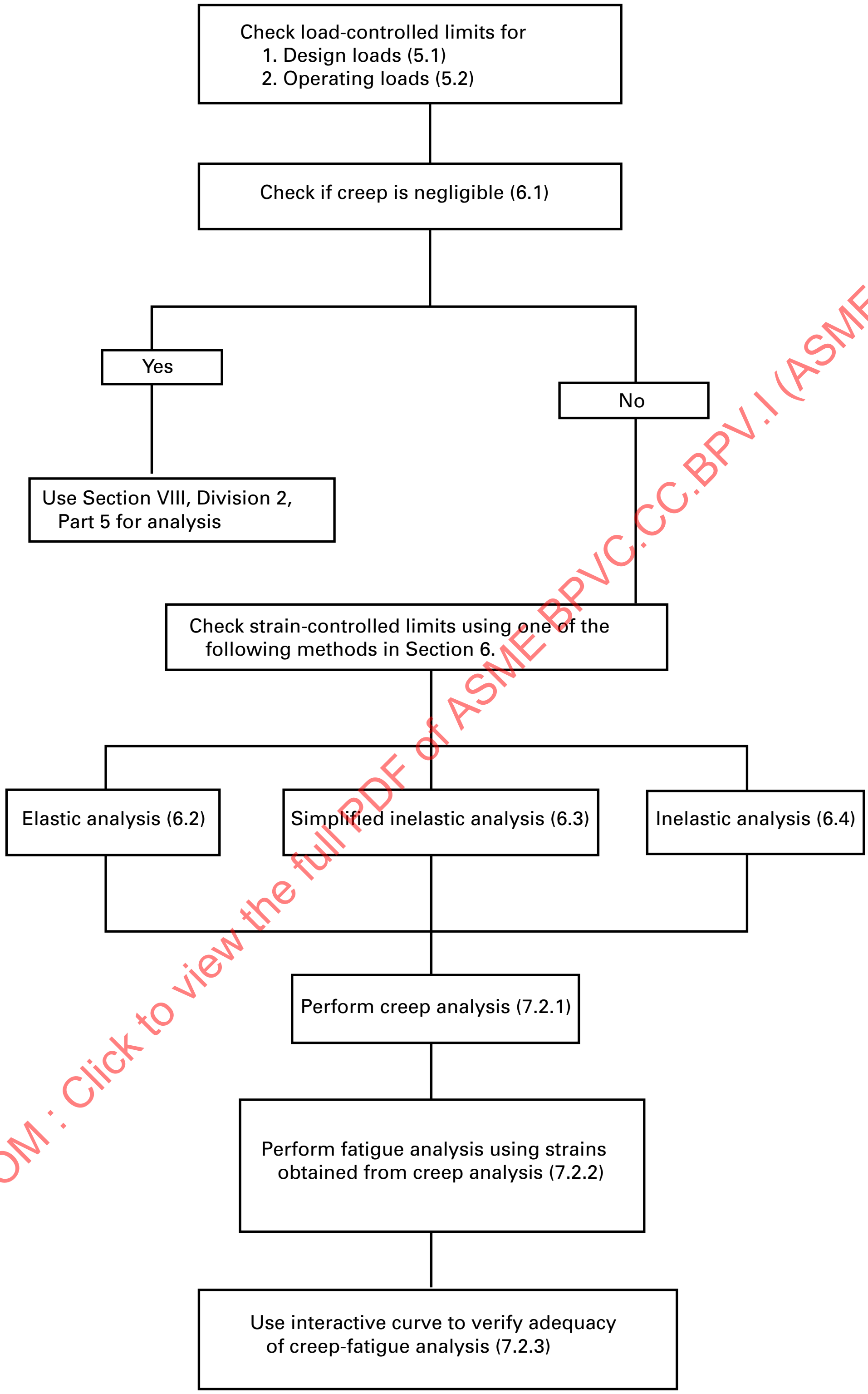


Figure 2
Flow Diagram for Load-Controlled Stress Limits

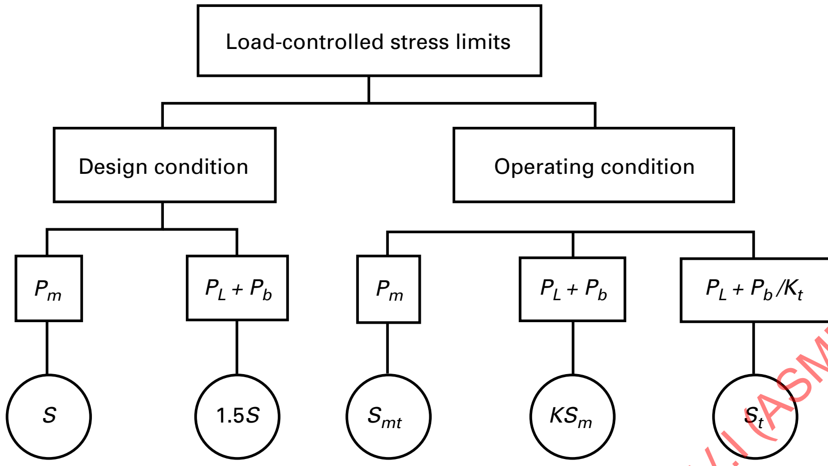


Figure 3
Use-Fractions for Membrane Stress

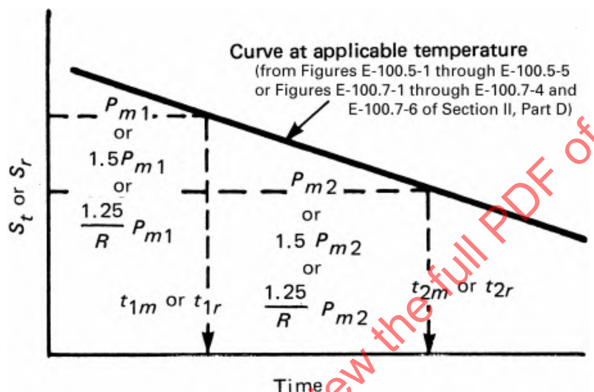


Figure 4
Use-Fractions for Membrane Plus Bending Stress

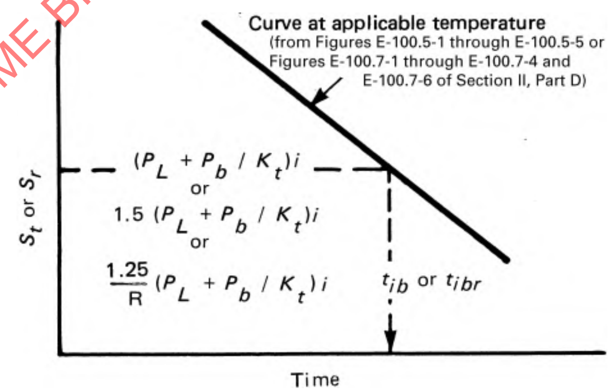
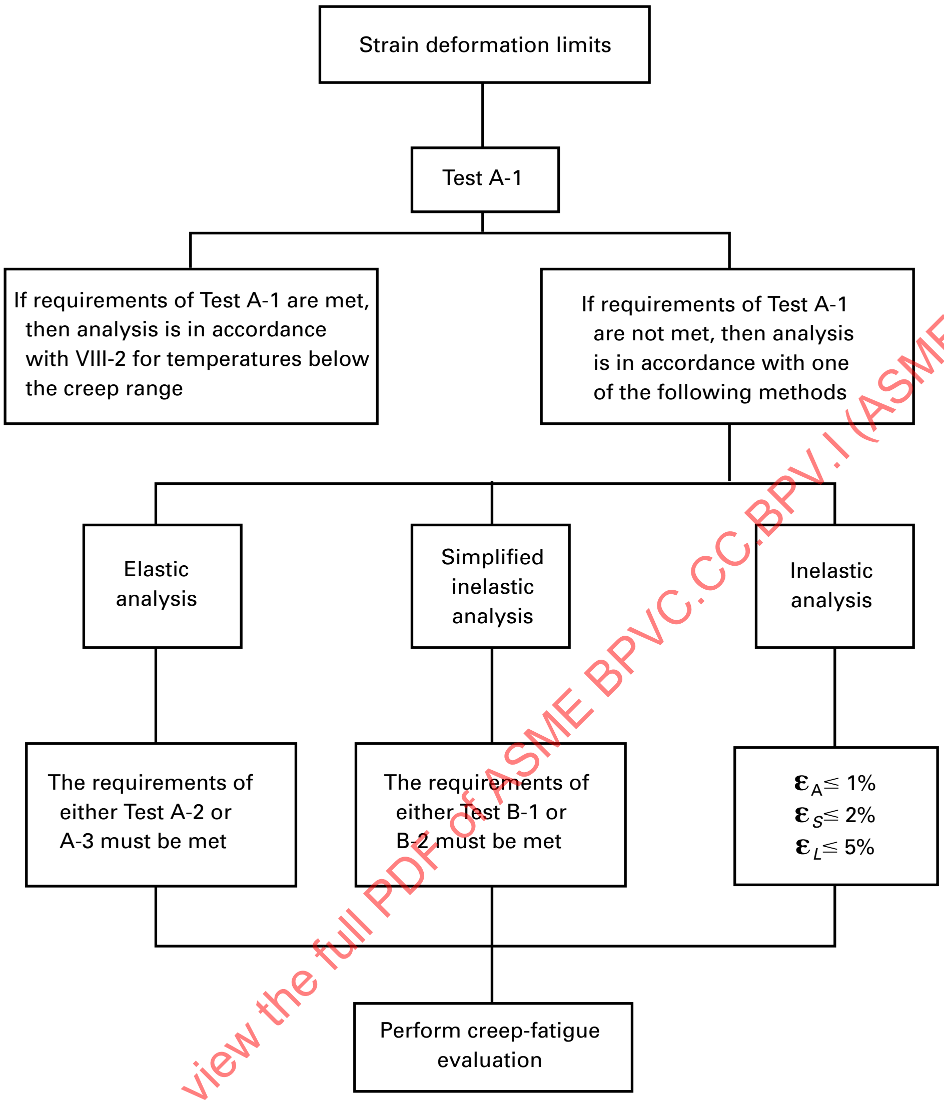


Figure 5
Requirements for Strain Limits



Legend:
ε_A = strain averaged through thickness
ε_L = local strain
ε_S = strain at surface

Figure 6
Stress Criteria for Test A-1

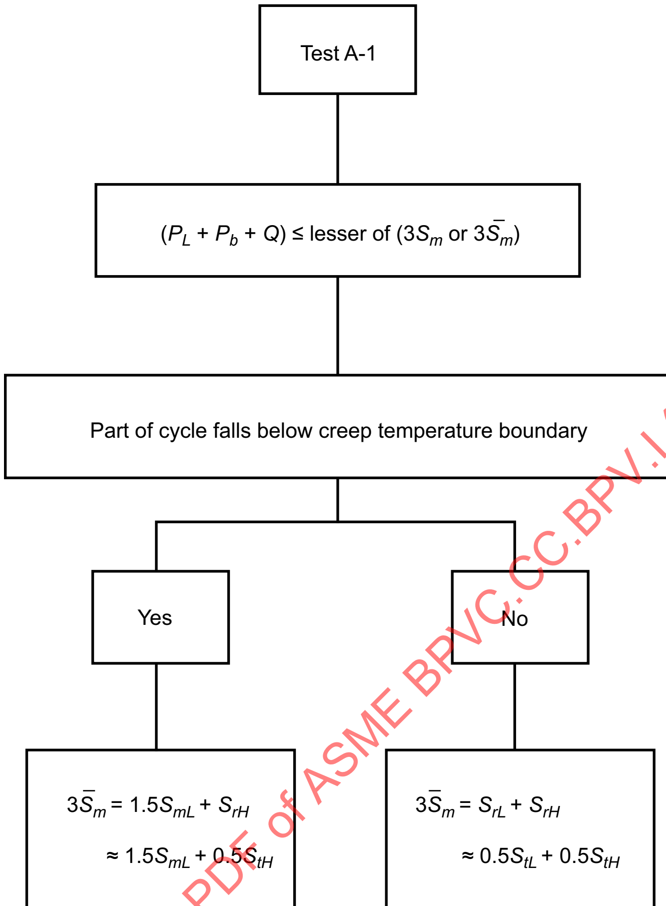


Figure 7
General Requirements for Tests A-2 and A-3

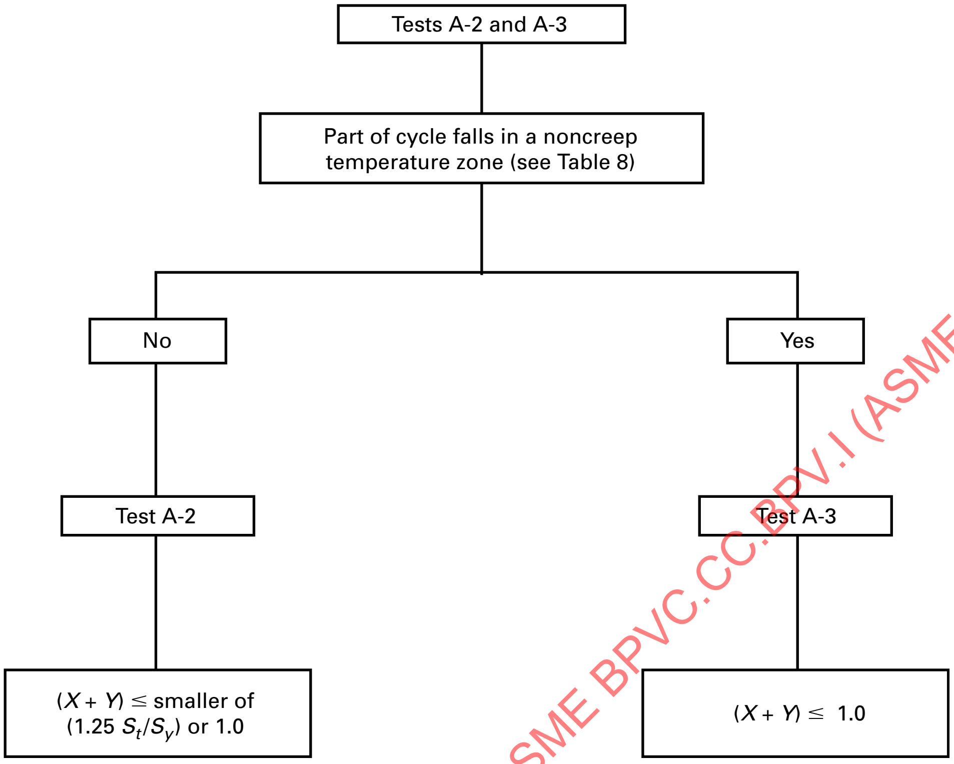
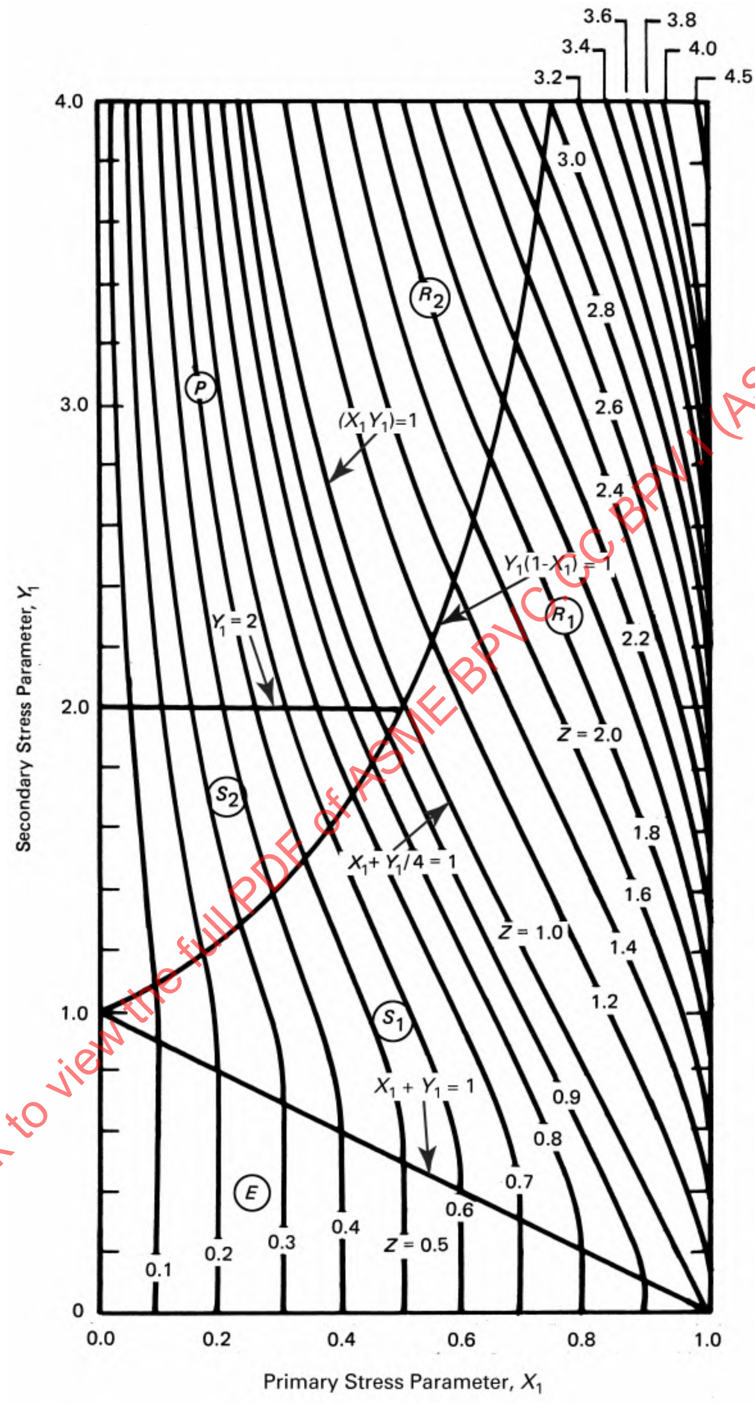


Figure 8
Effective Creep-Stress Parameter, *Z*, for Simplified Elastic Analysis Using Test B-1



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

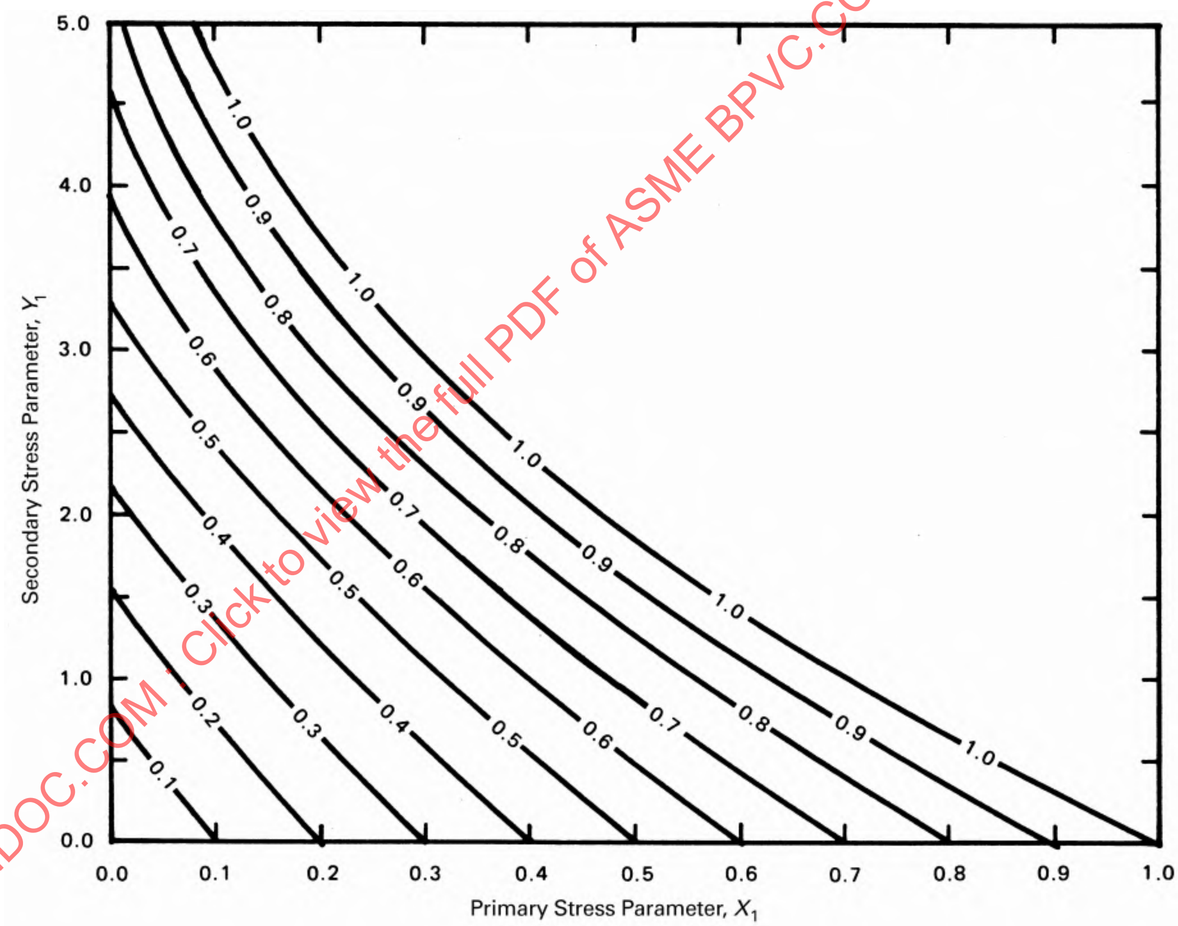
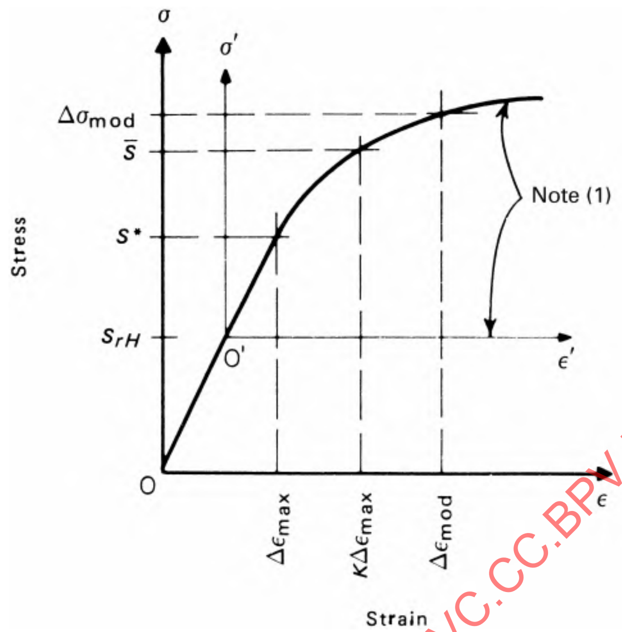
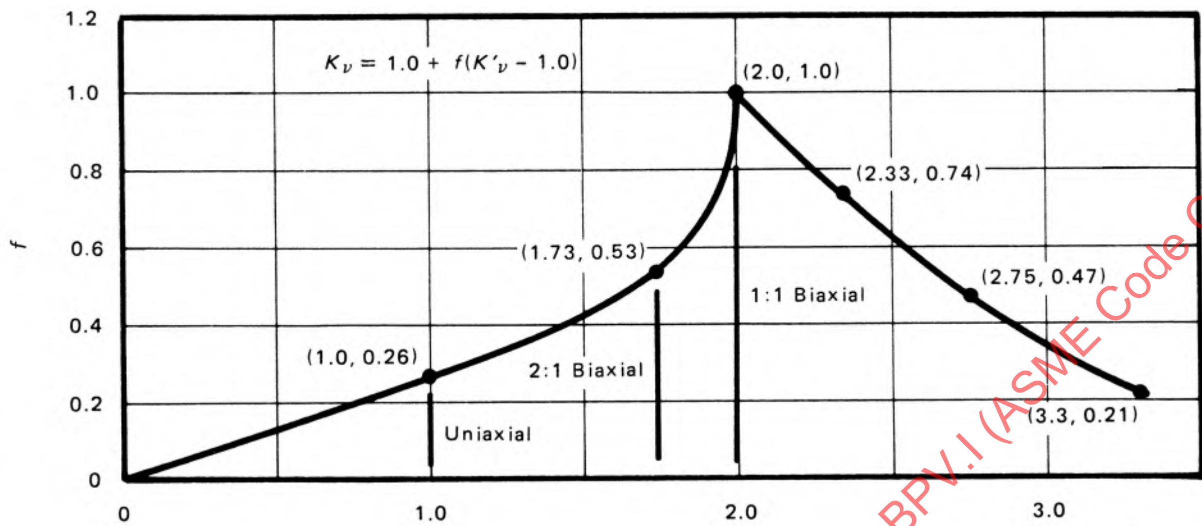


Figure 10
Stress-Strain Relationship



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.

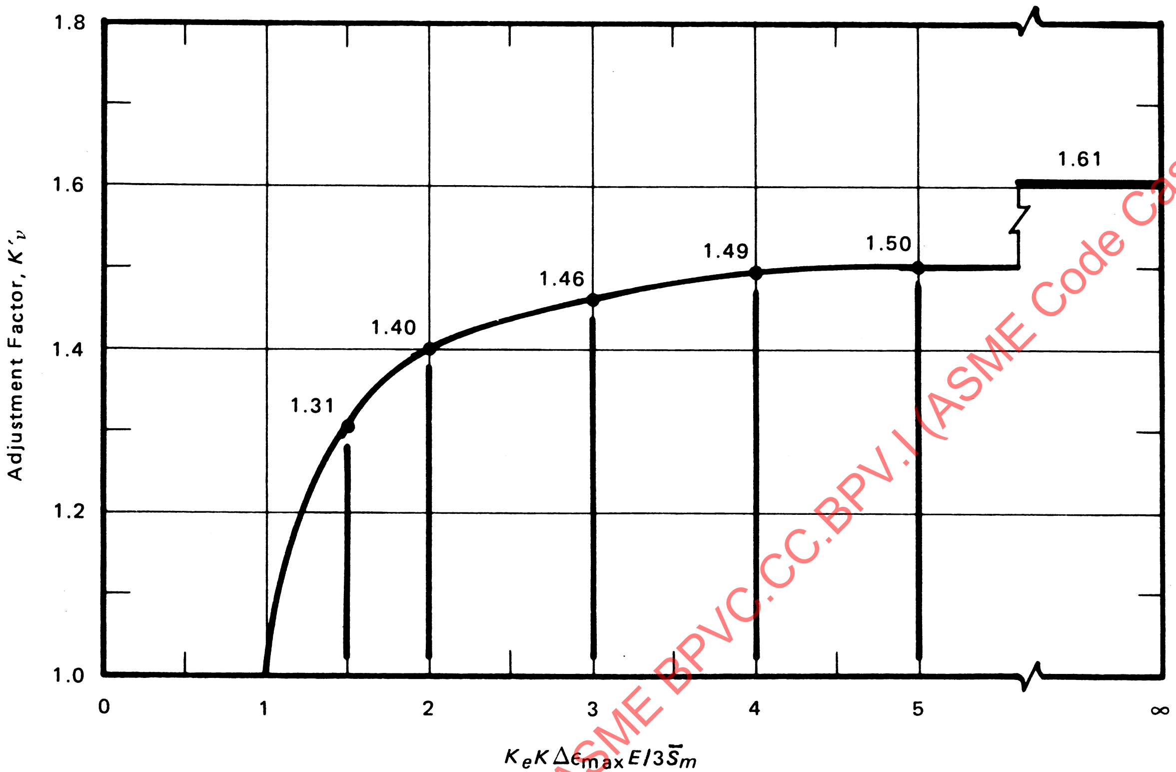
GENERAL NOTE: See equation below.

$$f = \frac{C_1 + C_2\left(\text{T.F.}\right) + C_3(\text{T.F.})^2 + C_4(\text{T.F.})^3}{1 + C_5(\text{T.F.}) + C_6(\text{T.F.})^2 + C_7(\text{T.F.})^3}$$

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'_ν can be expressed as follows:

(1) For $\gamma \le 1.0$

$$K'_\nu = 1.0$$

(2) For $1.0 < \gamma \le 50$

$$K'_\nu = \frac{C_1 + C_2\gamma}{1 + C_3\gamma + C_4\gamma^2}$$

(3) For $\gamma > 50$

$$K'_\nu = 1.61$$

where

C_1 = 1.88
C_2 = −2.5037475
C_3 = −1.6255583
C_4 = 0.0014771927
γ = $K_e K \Delta\epsilon_{max} E/3\bar{S}_m$

Figure 13
Method for Determining Stress Relaxation From Isochronous Curves

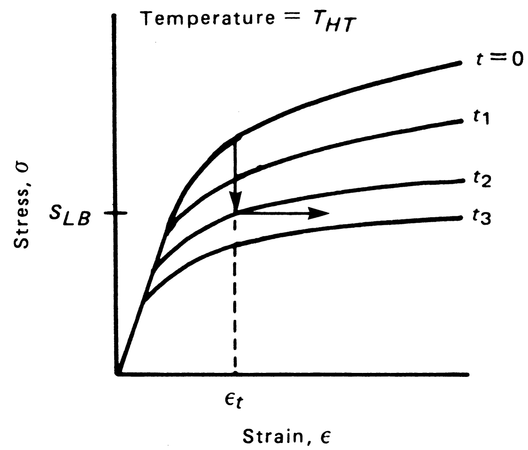


Figure 14
Stress-Relaxation Limits for Creep Damage

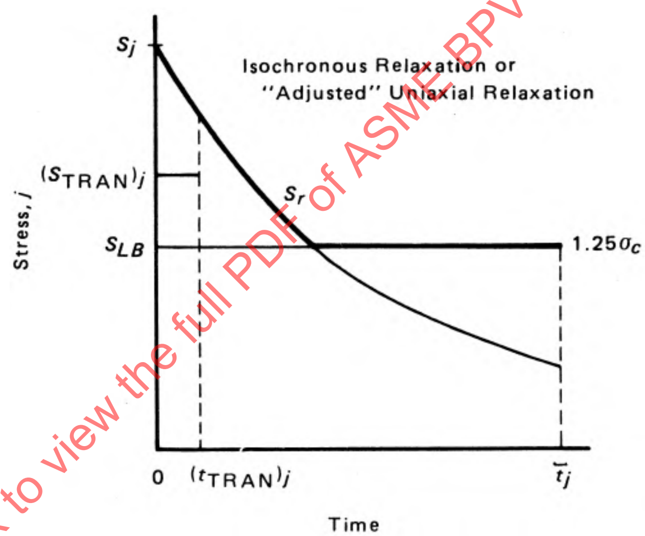
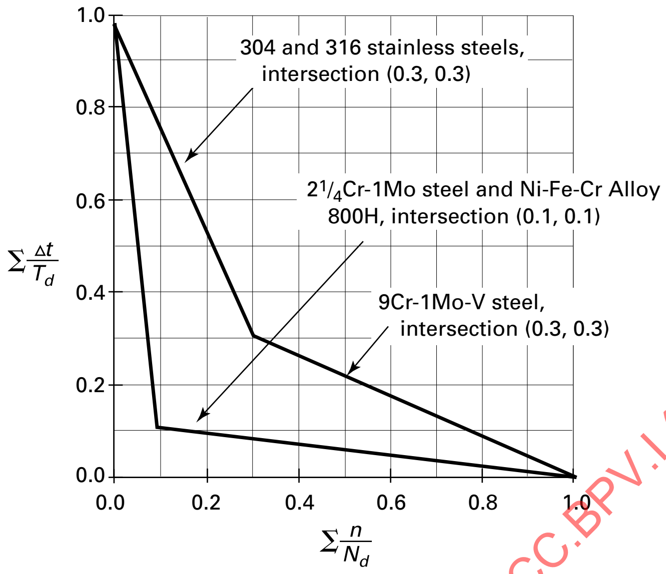


Figure 15
Creep-Fatigue Damage Envelope



GENERAL NOTE: The following equations apply to this figure.

(1) For 304 stainless steel, 316 stainless steel, and 9Cr–1Mo–V steel

(a) For $0 < \Sigma\left(\frac{n}{N_d}\right) \le 0.3$

$$\sum \frac{\Delta t}{T_d} = -\,2.333 \sum \frac{n}{N_d} + 1$$

(b) For $0.3 < \Sigma\left(\frac{n}{N_d}\right) \le 1.0$

$$\sum \frac{\Delta t}{T_d} = -\,0.429 \sum \frac{n}{N_d} + 0.429$$

(2) For nickel alloy 800H and 2.25Cr–1Mo steel

(a) For $0 < \Sigma\left(\frac{n}{N_d}\right) \le 0.1$

$$\sum \frac{\Delta t}{T_d} = -\,9 \sum \frac{n}{N_d} + 1$$

(b) For $0.1 < \Sigma\left(\frac{n}{N_d}\right) \le 1.0$

$$\sum \frac{\Delta t}{T_d} = -\,0.111 \sum \frac{n}{N_d} + 0.111$$

INTENTIONALLY LEFT BLANK

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-$^1/_4$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.

INTENTIONALLY LEFT BLANK

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 (2 060)	264 (1 820)	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	1 820
65	1 763
100	1 691

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 $^5/_{16}$ 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.

INTENTIONALLY LEFT BLANK

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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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)* X2CrNiN18-10
- *(6)* X5CrNiMo17-12-2
- *(7)* X5CrNi18-10
- *(8)* X5CrNiN19-9
- *(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
X2CrNiN18-10	80	39	45
X5CrNi18-10	75	31	36
X5CrNiMo17-12-2	75	32	38
X5CrNiN19-9	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
X2CrNiN18-10	550	270	310
X5CrNi18-10	520	210	250
X5CrNiMo17-12-2	520	220	260
X5CrNiN19-9	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
X2CrNiN18-10	22.9
X5CrNi18-10	21.4
X5CrNiMo17-12-2	21.4
X5CrNiN19-9	22.9
X6CrNiTi18-10	20.6

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
X2CrNiN18-10	157.1
X5CrNi18-10	148.6
X5CrNiMo17-12-2	148.6
X5CrNiN19-9	157.1
X6CrNiTi18-10	142.9

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
X2CrNiN18-10	304LN
X5CrNi18-10	304
X5CrNiMo17-12-2	316
X5CrNiN19-9	304N
X6CrNiTi18-10	321

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 confirming 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 cm^3) 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.

INTENTIONALLY LEFT BLANK

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 brazing[1] 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.

INTENTIONALLY LEFT BLANK

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 (l). 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 ($P_{max99\%}$) for the modules which shall be that pressure which provides probability of failure (POF) not greater than 1% (POF ≤ 1%; reliability ≥ 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 ($P_{max99\%}$) 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 (2 000°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 specificed 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 Whiteware 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).

$$f\left(x\right) = \left(\frac{x}{S_c}\right)^{m-1} \cdot \frac{m}{S_c} \cdot \exp\left[-\left(\frac{x}{S_c}\right)^m\right] \tag{1}$$

where $x > 0$

The two-parameter Weibull probability distribution function [eq. (2)] is also the failure probability $p(x)$ function.

$$p\left(x\right) = \int_0^x f\left(x'\right) \cdot dx' = 1 - \exp\left[-\left(\frac{x}{S_c}\right)^m\right] \tag{2}$$

where $x > 0$

The two-parameter reliability/survival function $L(x)$ is defined in eq. (3).

$$L\left(x\right) = 1 - p\left(x\right) = \exp\left[-\left(\frac{x}{S_c}\right)^m\right] \tag{3}$$

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).

$$\ln\{-\ln[L(x)]\} = + m \cdot \ln(x) - m \cdot \ln(S_c) \tag{4}$$

$$y(x) = a \cdot x + b \tag{5}$$

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, ..., 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.

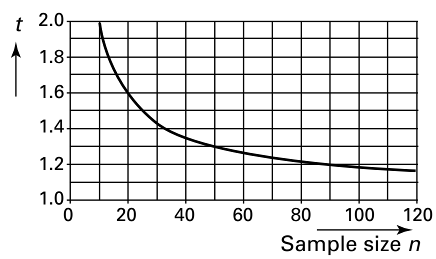
I-4 MAXIMUM ALLOWABLE WORKING PRESSURE BASED ON BURST PRESSURE TESTS

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 ($P_{max99\%}$) is calculated from eq. (9):

$$P_{max\,99\%} = \left(S_{c95\%} - \mu_{95\%}\right)\left(-\ln(0.99)\right)^{\frac{1}{m_{95\%}}} \tag{9}$$

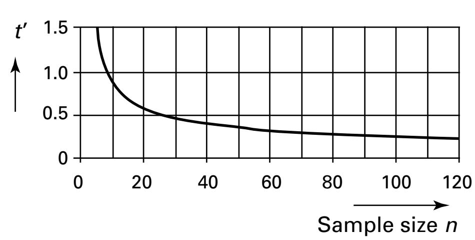
For two-parameter analysis, $\mu_{95\%}$ = 0.

Figure I-2-1
Correction Factor *t* of the Shape Parameter *m* of Two-Parameter Weibull Distribution



GENERAL NOTE: Confidence level, γ, = 0.95

Figure I-2-2
Correction Factor *t′* of the Characteristic Value S_c of Two-Parameter Weibull Distribution



GENERAL NOTE: Confidence level, γ, = 0.95

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

Case 2871-1
Use of SA-240/SA-240M, Types 316Ti, 316L, 439, and UNS S43932 With Thickness Less Than 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 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 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.

INTENTIONALLY LEFT BLANK

Case 2872
Use of SA-240/SA-240M, Plate Alloy Steel, Grades 304L and 316L With Thickness Less Than 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 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 1/8 in. (3 mm) may be used in HLW-302 potable water heater construction for maximum allowable working pressures up to 160 psi (1 100 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.

INTENTIONALLY LEFT BLANK

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 vales 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $^5/_{32}$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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/mm^3)

(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.

INTENTIONALLY LEFT BLANK

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 uppermost 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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) forthe 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 (1 050°C to 1 100°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} (7 750 kg/m^3)

(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. % [Note (1)]	20

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 × 10^{-6} (in./in./°F). Coefficient B is the mean coefficient of thermal expansion × 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 × 10^{-6} (mm/mm/°C). Coefficient B is the mean coefficient of thermal expansion × 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, W m^{-1} K^{-1}	Thermal Diffusivity, mm^2 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, *E*, $\times 10^6$ psi	Poisson's Ratio, ν
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, *E*, GPa	Poisson's Ratio, ν
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	32.4
ASTM A372/A372M, Grade P, Class 100	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	38.0
ASTM A372/A372M, Grade P, Class 120	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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $^3/_8$ 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 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.

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	...

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.

$$P_D + \frac{16M_E + 4F_EG}{\pi G^3} \leq (1 + F_M)P_R$$

(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)	**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)	**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].

INTENTIONALLY LEFT BLANK

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 $^5/_{16}$ 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 $^5/_{32}$ 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.

INTENTIONALLY LEFT BLANK

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} (7 870 kg/m^3)

(4) modulus of elasticity at 68°F (20°C): 29.7 × 10^6 psi (205 × 10^3 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 66⅔% 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 66⅔% 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $^3/_4$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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, Nonmandatory 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	1 000	960	918	899	885	870	857	844	832	822	811
SA-693, Grade XM-12, Class H1025	1 000	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	1 000	1 000	1 000	974	955	943
SA-693, Grade XM-12, Class H1075	1 000	1 000	1 000	974	955	943
SA-693, Grade 630, Class H1025	1 069	1 069	1 069	1 041	1 021	1 007
SA-693, Grade XM-12, Class H1025	1 069	1 069	1 069	1 041	1 021	1 007

NOTE: (1) The maximum design temperature for these materials is 288°C. Values above 288°C are provided only for the purpose of interpolation.

INTENTIONALLY LEFT BLANK

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 $^5/_{16}$ 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	
...	$3^1/_2$ (89)	$^1/_8$ (3)
> $3^1/_2$ (> 89)	$4^1/_2$ (114)	$^3/_{16}$ (5)
> $4^1/_2$ (> 114)	$6^5/_8$ (168)	$^1/_4$ (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 $^1/_8$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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/cm^3).

(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, $mm^2/s \times 10^{-6}$

Temperature, °C	Thermal Conductivity, W/m °C	Thermal Diffusivity, $mm^2/s \times 10^{-6}$
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 $\times 10^3$, and Poisson's Ratio

Temperature, °F	Modulus of Elasticity, ksi $\times 10^3$	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 $\times 10^3$, and Poisson's Ratio

Temperature, °C	Modulus of Elasticity, MPa $\times 10^3$	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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

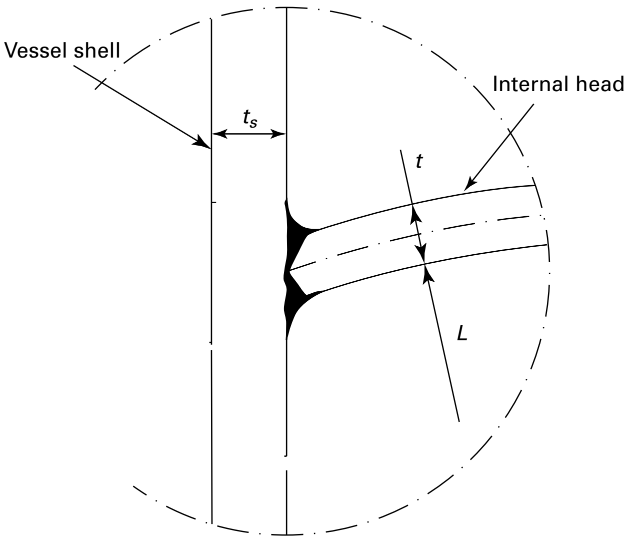
(c) The weld shall be full penetration through the head thickness (see Figure 1).

(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.

INTENTIONALLY LEFT BLANK

Case 2926
Use of 1Cr-$^1/_5$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-$^1/_5$Mo seamless pipe be used for the manufacture of cylindrical pressure vessels?

Reply: It is the opinion of the Committee that the 1Cr-$^1/_5$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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 $^3/_8$ 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 $^3/_8$ 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

	Minimum Elongation, %, for Wall Thickness, in. (mm)								
Test Piece Per JIS Z 2241	**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–$^1/_5$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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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:

$$C = C_0\left(\frac{E_o}{E}\right)^m \quad (4)$$

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 $\Delta K < \Delta K_a$, where ΔK_a 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

da/dN Values	Factors applicable for ΔK	C_0, in./cycle	*m*	$f(R_K)$	$g(P$, 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}	$\Delta K_a \le \Delta K < \Delta K_a$	2.54 E−12	6.5	$\dfrac{1 + 0.43R_K}{1 - R_K}$	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}	$\Delta K \ge \Delta K_c$	8.34 E−10	3.66	$\dfrac{1 + 2.0R_K}{1 - R_K}$	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

da/dN Values	Factors applicable for ΔK	C_0, m/cycle	*m*	$f(R_K)$	$g(P$, 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}	$\Delta K_a \le \Delta K < \Delta K_a$	3.5 E−14	6.5	$\dfrac{1 + 0.43R_K}{1 - R_K}$	For $P < 20.7$ MPa $0.071P^{0.51}$ For $P > 20.7$ MPa, $0.19 + 0.00763P$
da/dN_{high}	$\Delta K \ge \Delta K_c$	1.5 E−11	3.66	$\dfrac{1 + 2.0R_K}{1 - R_K}$	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.$^{0.5}$ — Carbon and Low Alloy Steel, $S_Y \le 90$ ksi	ΔK_a, ksi-in.$^{0.5}$ — High Strength Low Alloy Steel, $S_Y > 90$ ksi	ΔK_c, ksi-in.$^{0.5}$
$P \le 3{,}000$	$1.92(8.6 - 3.0R_k + 7.9R_k^2 - 9.4R_k^3)P^{-0.15}$	$2.02(9.6 + 2.7R_k + 0R_k^2 - 7.8R_k^3)P^{-0.16}$	$2.23(21.66 + 10R_k - 3.7R_k^2)P^{-0.18}$
$P > 3{,}000$	$2.59(10.6 - 3.7R_k + 9.8R_k^2 - 11.7R_k^3)P^{-0.21}$	$2.72(11.9 + 3.4R_k + 0R_k^2 - 9.6R_k^3)P^{-0.22}$	$3.16(27.4 + 12.7R_k - 4.8R_k^2)P^{-0.25}$

Table 2M
Stress Intensity Factor Limit Values

Values for *P*, MPa	ΔK_a, MPa-m$^{0.5}$ — Carbon and Low Alloy Steel, $S_Y \le 620$ MPa	ΔK_a, MPa-m$^{0.5}$ — High Strength Low Alloy Steel, $S_Y > 620$ MPa	ΔK_c, MPa-m$^{0.5}$
$P \le 20.7$	$(8.6 - 3.0R_k + 7.9R_k^2 - 9.4R_k^3)P^{-0.15}$	$(9.6 + 2.7R_k + 0R_k^2 - 7.8R_k^3)P^{-0.16}$	$(21.66 + 10R_k - 3.7R_k^2)P^{-0.18}$
$P > 20.7$	$(10.6 - 3.7R_k + 9.8R_k^2 - 11.7R_k^3)P^{-0.21}$	$(11.9 + 3.4R_k + 0R_k^2 - 9.6R_k^3)P^{-0.22}$	$(27.4 + 12.7R_k - 4.8R_k^2)P^{-0.25}$

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.

INTENTIONALLY LEFT BLANK

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 ±20°F (±11°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.

INTENTIONALLY LEFT BLANK

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)

$$a_{r1} = \frac{d_0}{2} - \sqrt{\frac{d_0^2}{4} - t\left(d_0 - t\right)\frac{f_w f_d}{E}} \qquad (1)$$

(b) Calculation of minimum weld leg a_{r2} (shear stress leg)

$$a_{r2} = \sqrt{2}\,\frac{\left[\left(d_0 - t\right)t f_d f_w\right]}{d_0 E} \qquad (2)$$

(c) *Nomenclature*

a_1 = actual tensile stress weld leg dimension (axis of the maximum ellipse inscribed in the weld) ($a_1 \le t$)
a_2 = actual shear stress weld leg dimension (axis of the maximum ellipse inscribed in the weld) ($a_2 \le d_g$)
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 tubesheets)
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).

$$f_r = \frac{\min(L_{\text{test }1}, L_{\text{test }2}, \ldots, L_{\text{test }n})}{A_t S_t}$$

where

A_t = test tube cross sectional area
$L_{\text{test }1\ \ldots,\ n}$ = 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

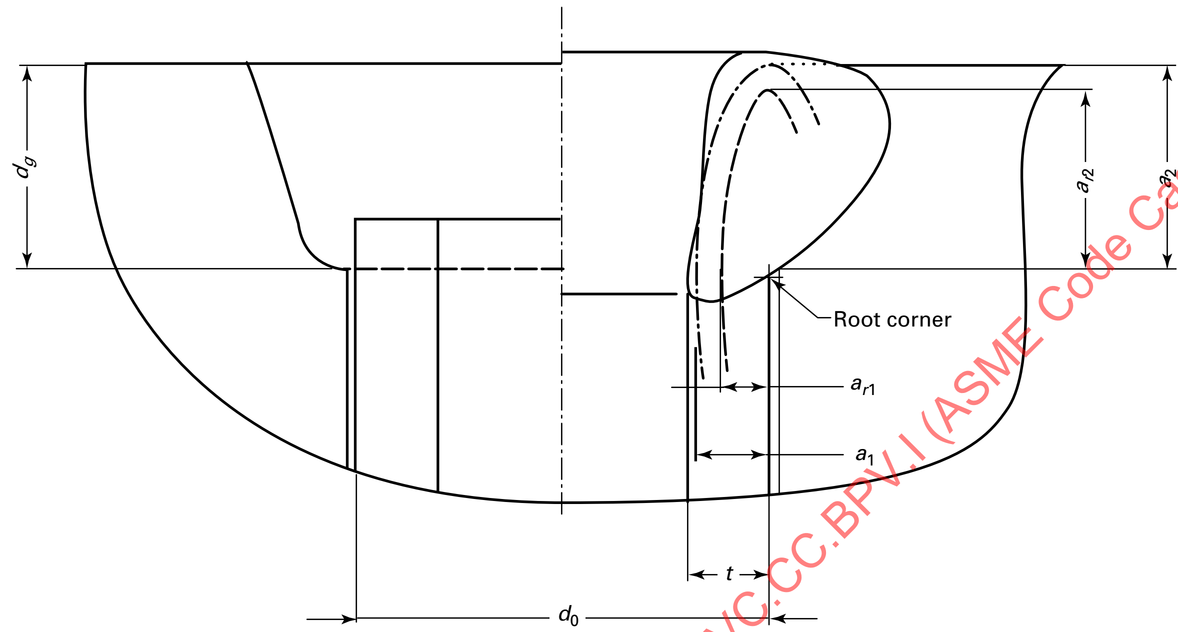


Figure 2
Weld Leg

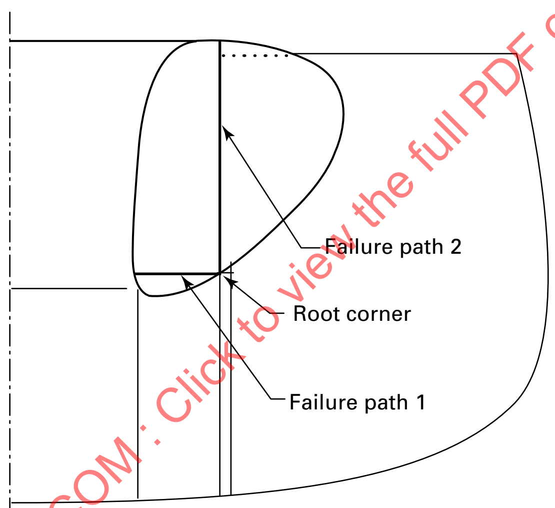


Table 1
Production NDE and Inspections

Adopted Weld Efficiency, *E*	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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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. (1 880 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.

INTENTIONALLY LEFT BLANK

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 $^3/_8$ in. (10 mm) thick, is it permitted to use a bevel with a depth greater than $^1/_3$ the tubesheet thickness?

Reply: It is the opinion of the Committee that water heater tubes may be attached by welding, to tubesheets less than $^3/_8$ in. (10 mm) thick, with a bevel of depth greater than $^1/_3$ 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.

INTENTIONALLY LEFT BLANK

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 ($^1/_4$ 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 Lame'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

$$\delta = \left[R^2\left(P_iR_i^{\,2} - P_oR_o^{\,2}\right)\left(1 - 2\mu\right) + \left(P_i - P_o\right)\left(R_i^{\,2}R_o^{\,2}\right)\left(1 + \mu\right)\right]/\left[ER\left(R_o^{\,2} - R_i^{\,2}\right)\right] \quad (1)$$

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

$$\delta_{sopi} - \delta_{sopf} = \delta_{cipf} - \delta_{cipo} \quad (2)$$

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_{cipo} = 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

$$P_f = \left(P_iK_5 + P_oK_6\right)/\left(K_2 + K_3 + K_4\right) \quad (3)$$

where

$K_1 = [E_s(R_2^{\,2} - R_1^{\,2})]/[E_c(R_3^{\,2} - R_2^{\,2})]$

$K_2 = K_1[R_2^{\,2}(1 - 2\mu_c) + R_3^{\,2}\,(1 + \mu_c)$

$K_3 = R_2^{\,2}\,(1 - 2\mu_c)$

$K_4 = R_1^{\,2}\,(1 + \mu_s)$

$K_5 = R_1^{\,2}\,(2 - \mu_s)$

$K_6 = K_1R_3^{\,2}(2 - \mu_c)$

Once the value of P_f is obtained from eq. (3), then the circumferential stress in the steel cylinder is obtained from Lame's equation as {Reference [2]}.

$$\sigma_{\theta s} = \left[P_iR_i^{\,2} - P_fR_2^{\,2} + \left(P_i - P_f\right)\left(R_1^{\,2}R_2^{\,2}/R^2\right)\right]/\left(R_2^{\,2} - R_1^{\,2}\right) \quad (4)$$

While the circumferential stress in the concrete cylinder is given by

$$\sigma_{\theta c} = \left[P_fR_2^{\,2} - P_oR_3^{\,2} + \left(P_f - P_o\right)\left(R_2^{\,2}R_3^{\,2}/R^2\right)\right]/\left(R_3^{\,2} - R_2^{\,2}\right) \quad (5)$$

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 = $1.0/d$.

$$t_w = \left(\pi d^2/4\right)\left(1/d\right) = \pi d/4 \tag{6}$$

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 po 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

δ of the outer surface of the inner steel shell =
δ of the inner surface of the concrete shell (8)

Substituting eq. (-a)(1) into eq. (8), rearranging terms, and using the terminology of Figure 8 results in

$$P_1(C_1 + C_2) - C_3 P_2 = C_4 \tag{9}$$

Similarly,

δ of the outer surface of the concrete shell =
δ of the inner surface of the outer steel shell (10)

Substituting eq. (-a)(1) into eq. (10), rearranging terms, and using the terminology of Figure 8 gives

$$C_5 P_1 - P_2(C_6 + C_7) = C_8 \tag{11}$$

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

$$\begin{aligned}
C_1 &= (E_c/E_s)(R_2{}^2 - R_1{}^2)(R_1)[(R_1{}^2 + R_i{}^2) - \mu_s(R_1{}^2 - R_i{}^2)]\\
C_2 &= (R_1{}^2 - R_i{}^2)(R_1)[(R_2{}^2 + R_1{}^2) + \mu_c(R_2{}^2 - R_1{}^2)]\\
C_3 &= 2(R_1{}^2 - R_i{}^2)R_1R_2{}^2\\
C_4 &= 2(E_c/E_s)(R_2{}^2 - R_1{}^2)p_iR_i{}^2R_1\\
C_5 &= 2(R_o{}^2 - R_2{}^2)R_1{}^2R_2\\
C_6 &= (R_o{}^2 - R_2{}^2)(R_2)[(R_2{}^2 + R_1{}^2) - \mu_c(R_2{}^2 - R_1{}^2)]\\
C_7 &= (E_c/E_s)(R_2{}^2 - R_1{}^2)(R_2)[(R_o{}^2 + R_2{}^2) + \mu_s(R_o{}^2 - R_2{}^2)]\\
C_8 &= -2(E_c/E_s)(R_2{}^2 - R_1{}^2)p_oR_2R_o{}^2\\
C_9 &= C_8(C_1 + C_2) - C_4C_5\\
C_{10} &= C_3C_5 - (C_1 + C_2)(C_6 + C_7)\\
C_{11} &= C_4 + (C_3C_9/C_{10})\\
C_{12} &= C_1 + C_2
\end{aligned}$$

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 Lame's equation using P_i and P_f. The stress in the concrete shell shall be obtained from Lame'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

$$\sigma_{\theta s} = \frac{P_iR_i^2 + P_i\left(\dfrac{R_i^2R_f^2}{r^2}\right) - P_fR_f^2 - P_f\left(\dfrac{R_i^2R_f^2}{r^2}\right)}{R_f^2 - R_i^2} \tag{14}$$

(-2) Circumferential stress in concrete shell

$$\sigma_{\theta c} = \frac{P_fR_f^2 + P_f\left(\dfrac{R_f^2R_o^2}{r^2}\right) - P_oR_o^2 - P_o\left(\dfrac{R_f^2R_o^2}{r^2}\right)}{R_o^2 - R_f^2} \tag{15}$$

(-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.

deflection of the outside surface of the steel-layered shell due to P_f = deflection of inside surface of the concrete shell due to P_f and P_o (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

$$\sigma_\theta = \left[E_s/\left(1 - \mu_s^2\right)\right]\left(\varepsilon_\theta + \mu_s\varepsilon_L\right) \quad (17)$$

$$\sigma_L = \left[E_s/\left(1 - \mu_s^2\right)\right]\left(\varepsilon_L + \mu_s\varepsilon_\theta\right) \quad (18)$$

(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]}.

$$\delta_I = \left[R_iP_i\left(R_o^2 + R_i^2\right) + \mu_sR_iP_i\left(R_o^2 - R_i^2\right) - 2P_oR_iR_o^2\right]/E_s\left(R_o^2 - R_i^2\right) \quad (19)$$

Similarly, the deflection of the outside surface of a cylinder due to internal and external pressure is given by {Reference [2]}.

$$\delta_o = \left[2P_iR_i^2R_o - R_oP_o\left(R_o^2 + R_i^2\right) + \mu_sR_oP_o\left(R_o^2 - R_i^2\right)\right]/E_s\left(R_o^2 - R_i^2\right) \quad (20)$$

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

$$\Delta_i = \left(P_fR_f\right)\left[R_o^2\left(1 + \mu_s\right) + R_f^2\left(1 - \mu_s\right)\right]/E_s\left(R_o^2 - R_f^2\right) \quad (24)$$

Similarly, from eq. (19), the deflection of the outside surface of inner layer t_i due to interface pressure P_f is

$$\Delta_o = \left(P_fR_f\right)\left[R_f^2\left(-1 + \mu_s\right) - R_i^2\left(1 + \mu_s\right)\right]/E_s\left(R_f^2 - R_i^2\right) \quad (25)$$

Substituting eqs. (21), (22), (24), and (25) into eq. (23), and solving for the unknown interface pressure P_f gives

$$P_f = K_3/\left[R_f\left(K_1 - K_2\right)\right] \quad (26)$$

where

$$K_1 = R_o^2(1 + \mu_s) + R_f^2(1 - \mu_s)/[R_o^2 - R_f^2]$$
$$K_2 = R_f^2(-1 + \mu_s) - R_i^2(1 + \mu_s)/[R_f^2 - R_i^2]$$
$$K_3 = (E_s)(K)(w)(n)/2\pi)$$

(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,

$$\sigma_\theta = \left[-P_o R_o^{\,2} - P_o\left(R_i^{\,2} R_o^{\,2}/R^2\right)\right] / \left(R_o^{\,2} - R_i^{\,2}\right) \tag{27}$$

(2) Due to internal pressure P_i,

$$\sigma_\theta = \left[P_i R_i^{\,2} + P_i\left(R_i^{\,2} R_o^{\,2}/R^2\right)\right] / \left(R_o^{\,2} - R_i^{\,2}\right) \tag{28}$$

(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 calculated 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

$$H_1 - H_2 - H_3 = 0 \tag{29}$$

$$M_1 - M_2 = 0 \tag{30}$$

$$\delta_s = \delta_h \tag{31}$$

$$\delta_s = \delta_c \tag{32}$$

$$\theta_s = \theta_h \tag{33}$$

$$\theta_s = \theta_c \tag{34}$$

(1) *Head Equations*

$$\delta_h = \delta_{hPi} - \delta_{hH1} + \delta_{hM1} \tag{35}$$

$$\theta_h = \theta_{hPi} + \theta_{hH1} - \theta_{hM1} \tag{36}$$

where

δ_{hPi} = radial deflection of head due to internal pressure P_i
= $P_i R_h^{\,2}(1-\mu_h)/(2E_h t_h)$
δ_{hH1} = radial deflection of head due to shear force H_1
= $H_1 R_h (2\lambda)/(E_h t_h)$
δ_{hM1} = radial deflection of head due to bending moment M_1
= $2M_1\lambda^2/(E_h t_h)$
θ_{hPi} = rotation of head due to internal pressure P_i
= 0
θ_{hH1} = rotation of head due to shear force H_1
= $2H_1\lambda^2/(E_h t_h)$
θ_{hM1} = rotation of head due to bending moment M_1
= $4M_1\lambda^3/(E_h R_h t_h)$

and where $\lambda = [3(1 - \mu_h^{\,2})(R_h/t_h)^2]^{0.25}$

(2) *Steel Shell Equations*

$$\delta_s = \delta_{sPi} - \delta_{sPf} + \delta_{sH2} + \delta_{sM2} \tag{37}$$

$$\theta_s = \theta_{sPi} - \theta_{sPf} + \theta_{sH2} + \theta_{sM2} \tag{38}$$

where

δ_{sPi} = radial deflection of steel shell due to internal pressure P_i
= $P_i R_s^{\ 2}[1 - (\mu_s/2)]/(E_s t_s)$

δ_{sPf} = radial deflection of steel shell due to interface pressure P_f
= $P_f R_s^{\ 2}/(E_s t_s)$

δ_{sH2} = radial deflection of steel shell due to shear force H_2
= $H_2/(2\beta_s^{\ 3} D_s)$

δ_{sM2} = radial deflection of steel shell due to bending moment M_2
= $M_2/(2\beta_s^{\ 2} D_s)$

θ_{sPi} = rotation of steel shell due to internal pressure P_i
= 0

θ_{sPf} = rotation of steel shell due to external pressure P_f
= 0

θ_{sH2} = rotation of steel shell due to shear force H_2
= $H_2/(2\beta_s^{\ 2} D_s)$

θ_{sM2} = rotation of steel shell due to bending moment M_2
= $M_2/(\beta_s^{\ 2} D_s)$

and where

$$\beta_s = \left[3\left(1 - \mu_s^{\ 2}\right)/(R_s t_s)^2\right]^{0.25}$$

$$D_s = E_s t_s^{\ 3}/\left[12\left(1 - \mu_s^{\ 2}\right)\right]$$

(3) Concrete Shell Equations

$$\delta_c = \delta_{cPf} - \delta_{cPo} + \delta_{cH3} \qquad (39)$$

$$\theta_c = \theta_{sPf} + \theta_{cPo} + \theta_{cH3} \qquad (40)$$

where

δ_{cPf} = radial deflection of steel shell due to internal pressure P_i
= $P_f R_c^{\ 2}/(E_c t_c)$

δ_{cPo} = radial deflection of steel shell due to interface pressure P_o
= $P_o R_c^{\ 2}/(E_c t_c)$

δ_{cH3} = radial deflection of steel shell due to shear force H_3
= $H_3/(2\beta_c^{\ 3} D_c)$

θ_{cPf} = radial deflection of concrete shell due to interface pressure P_f
= 0

θ_{cPo} = radial deflection of concrete shell due to pre-stress pressure P_o
= 0

θ_{cH3} = radial deflection of concrete shell due to shear force H_3
= $H_3/(2\beta_c^{\ 2} D_c)$

and where

$$\beta_c = \left[3\left(1 - \mu_c^{\ 2}\right)/(R_c t_c)^2\right]^{0.25}$$

$$D_c = E_c t_c^{\ 3}/\left[12\left(1 - \mu_c^{\ 2}\right)\right]$$

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.

$$[K][F] = [C] \qquad (41)$$

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

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} = $1/(2\beta_c^{\ 2} D_c)$

(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

$\delta_h = (1/E_h t_h)[(0.5)(P_i R_h^2)(1 - \mu_h) - 2H_1 R_h \lambda + 2M_1 \lambda^2]$

$\delta_s = (P_i R_s^2)(1 - \mu_s/2)/(E_s t_s - (P_f R_s^2)/(E_s t_s) + H_2/(2\beta_s^3 D_s) + M_2/(2\beta_s^2 D_s)$

$\delta_c = (P_f R_c^2)/(E_c t_c) - (P_o R_c^2)/(E_c t_c) + H_3/(2\beta_c^3 D_c)$

(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_{cpfpo} = deflection of concrete shell due to interface pressure, P_f, and outside pressure, P_o
δ_{sPiPf} = 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

(a) ASME References

[1] M. Jawad, Y. Wang, and Z. Feng. 2020. *"Steel-Concrete Composite Pressure Vessels for Hydrogen Storage at High Pressures."* ASME Journal of Pressure Vessel Technology.
[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

AWWA C300 (2011) Reinforced Concrete Pressure Pipe, Steel-Cylinder Type

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

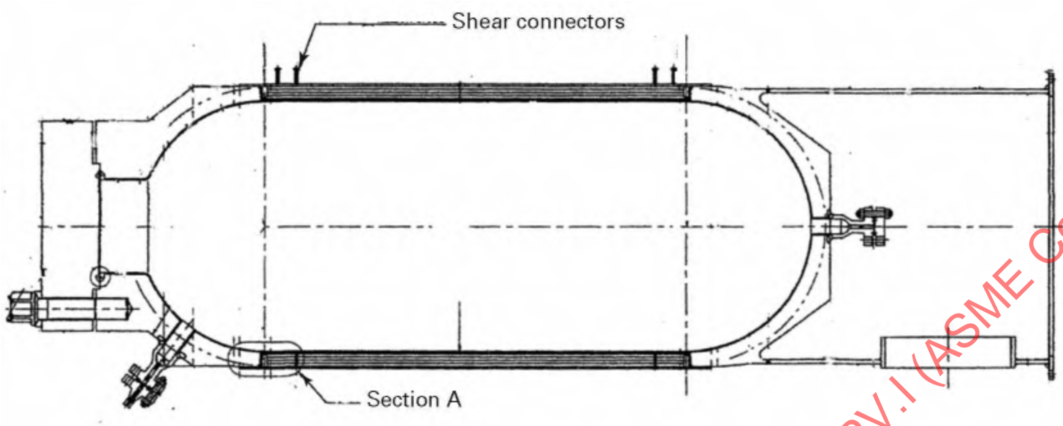
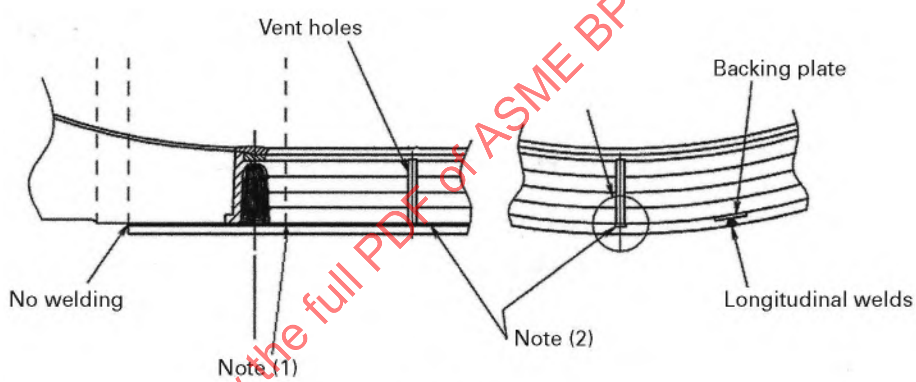


Figure 2
Detail of Head-to-Steel Layered Shell Junction



Detail A

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

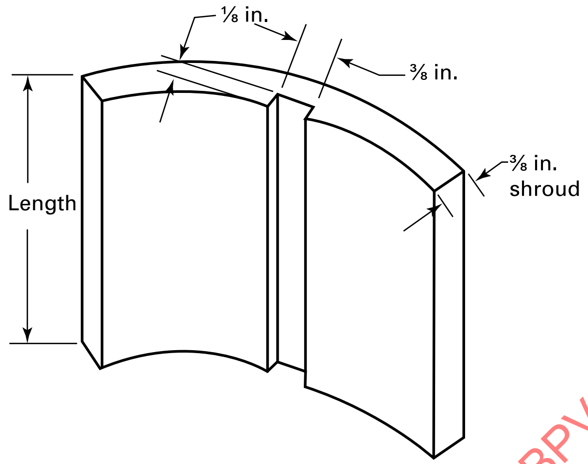


Figure 4
Head-to-Layered Shell Detail

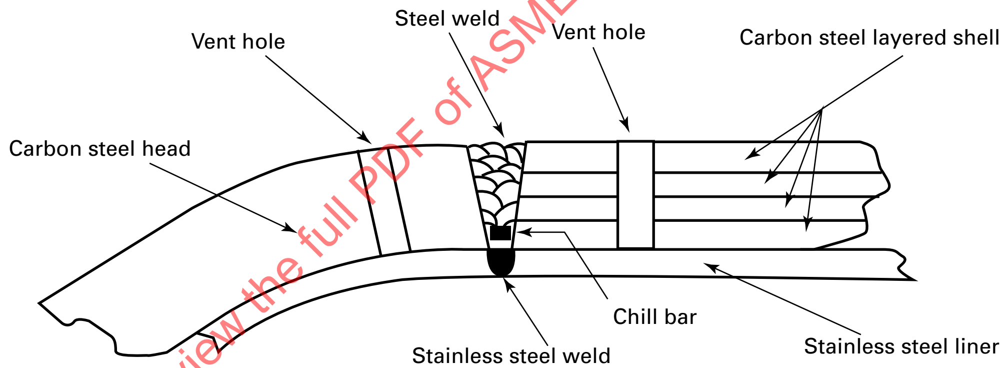


Figure 5
Example of Outer Concrete Shell

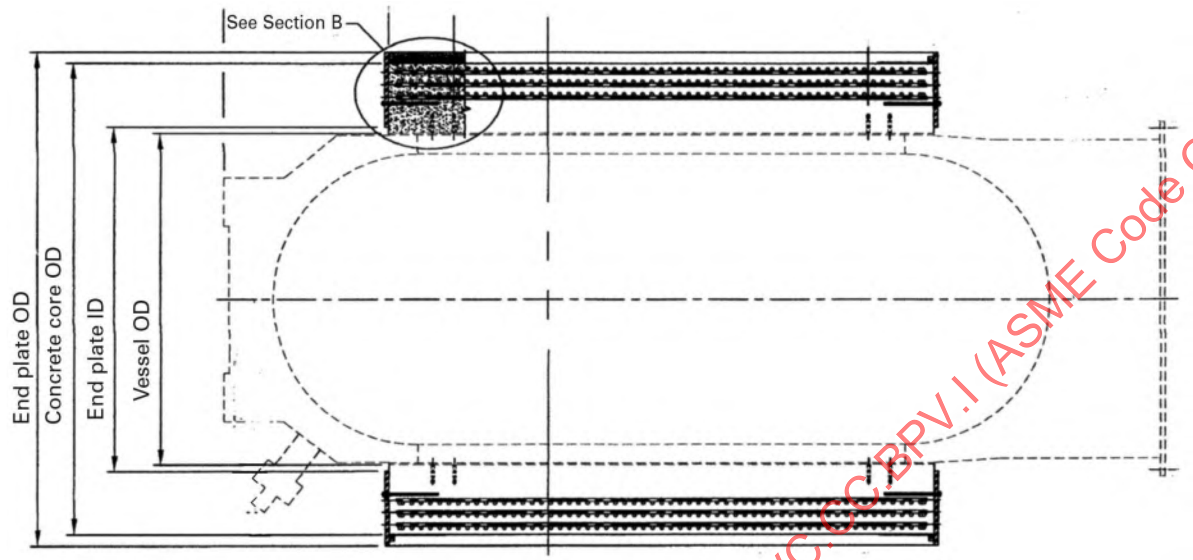
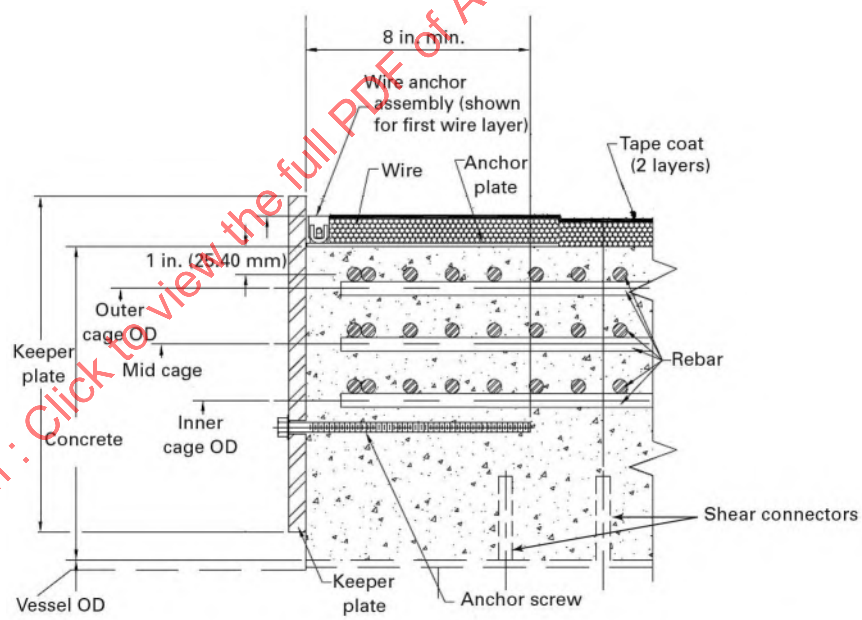


Figure 6
Details of Concrete Reinforcement



Section B (Typical Both Ends)

Figure 7
Steel-Concrete Composite Shell

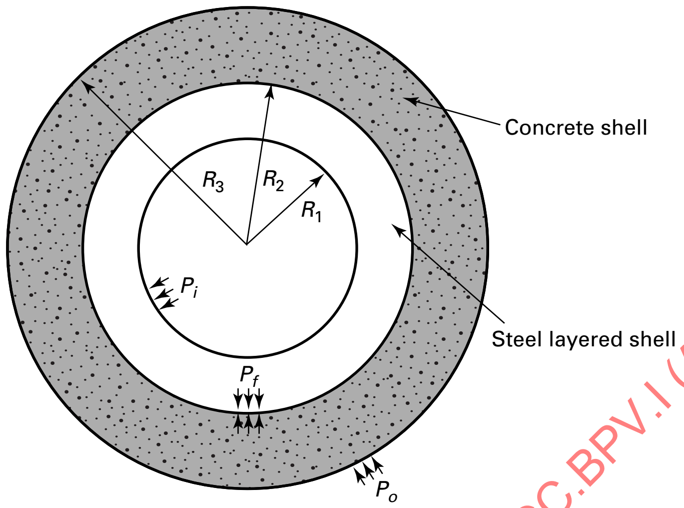


Figure 8
Steel-Concrete-Steel Interaction

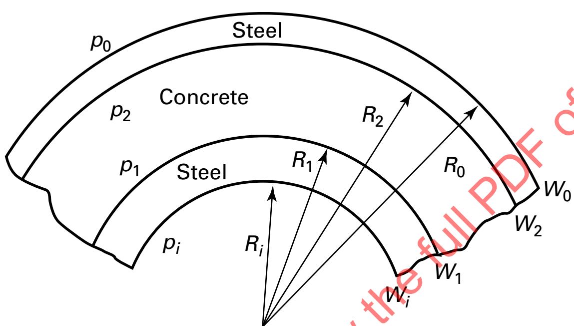


Figure 9
Layered Vessel

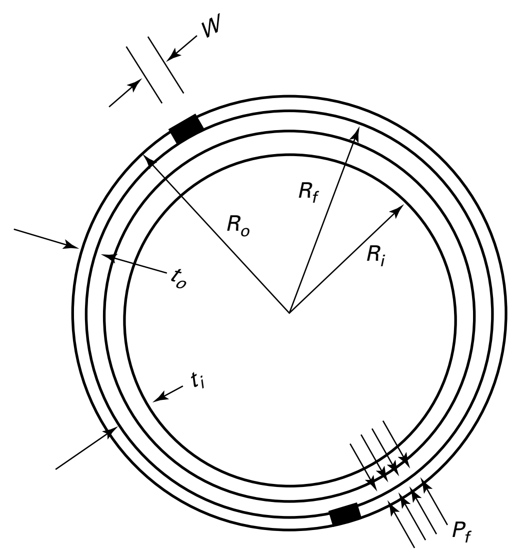


Figure 10
Stress from Strain Gage Measurements Versus Stress from Assumed Value of *K*

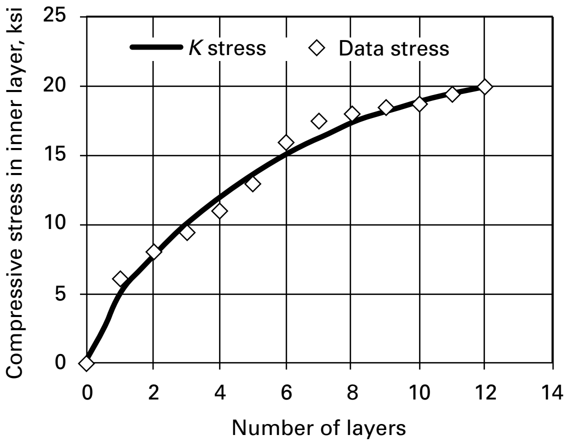


Figure 11
Wrapping Stress Distribution Through Thickness

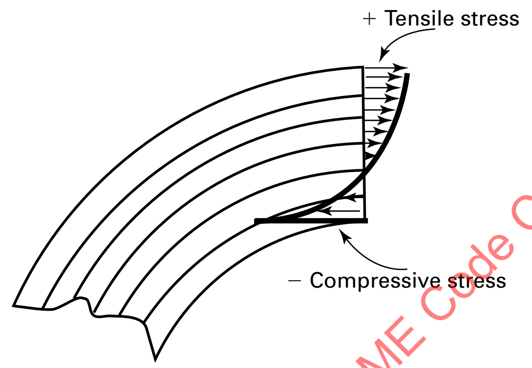
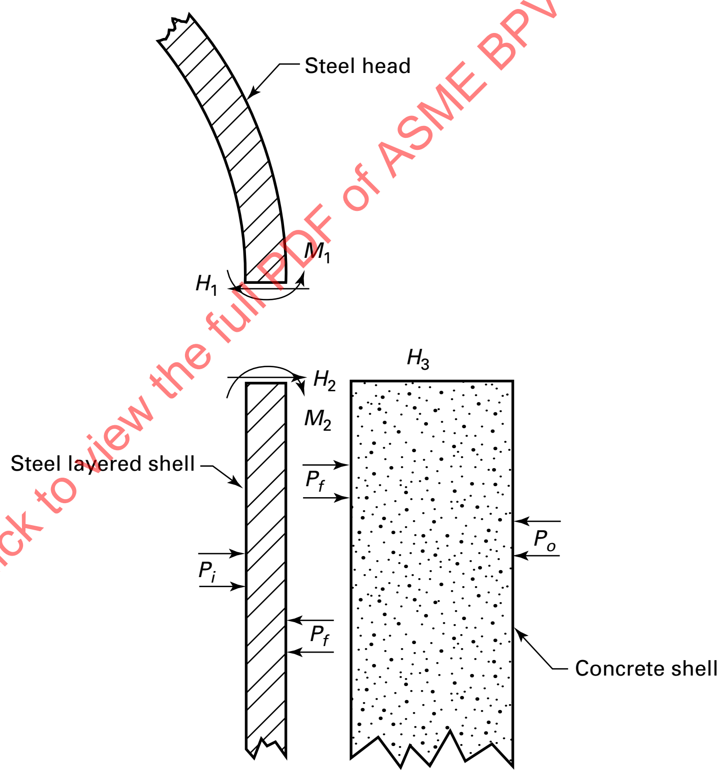


Figure 12
Head-to-Shell Forces



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–½Mo = 20

(3) 1¼Cr–½Mo, 2¼Cr–1Mo, 5Cr–½Mo, 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.(0.64S_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 $^2/_3{}^*S_y$ for ferritic materials and 0.9^*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:

$$\mathrm{LMP}(t_{100{,}000},\ T_{Di})_i = \frac{\left(T_{Di} + 460\right)\left[C_{\mathrm{LMP}} + \mathrm{Log}_{10}\left(100{,}000\right)\right]}{1{,}000} = \frac{(T_{Di} + 460)(C_{\mathrm{LMP}} + 5)}{1{,}000}$$

(5) Using the LMP that was determined in (4), calculate an allowable duration, $(t_{\mathrm{all}})i$ 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:

$$\mathrm{LMP}_i = \frac{\left(T_i + 460\right)\left\{C_{\mathrm{LMP}} + \mathrm{Log}_{10}\left[\left(t_{\mathrm{all}}\right)_i\right]\right\}}{1{,}000}$$

$$\left(t_{\mathrm{all}}\right)_i = 10\exp\left[\left(\frac{1{,}000\cdot \mathrm{LMP}_i}{T_i + 460}\right) - C_{\mathrm{LMP}}\right]$$

(6) Compute the life fraction, λ_i, for each operating condition:

$$\lambda_i = t_i/\left(t_{\mathrm{all}}\right)_i$$

(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	[σ_{sm}/0.25] for large-end junction
		[σ_{sm}/1.25] for small-end junction
		[(σ_{sm} ± σ_{sb})/2] for large-end junction
		[(σ_{sm} ± σ_{sb})/2] for small-end junction
		[$\sigma_{\vartheta m}$/1.25] for large-end junction
		[$\sigma_{\vartheta m}$/1.25] for small-end junction
		[($\sigma_{\vartheta m}$ ± $\sigma_{\vartheta b}$)/2] for large-end junction
		[($\sigma_{\vartheta m}$ ± $\sigma_{\vartheta b}$)/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}
		$\sigma_{\vartheta m}$
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_{rx} factors shall be determined in accordance with this Case	P_L/1.25
U-tube tubesheets	Section VIII, Division 1, UHX-12	σ/1.67
		1.25τ
		[σ_c/1.25] and/or [σ_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	σ/1.25
		1.25τ
		[σ_c/1.25] and/or [σ_s/1.25] for fixed tubesheets with welded channels and/or shells, when considering design loading cases
		[σ_c/2] and/or [σ_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	σ/1.25
		1.25τ
		[σ_c/1.25] and/or [σ_s/1.25] for floating tubesheets with welded channels and/or shells, when considering design loading cases
		[σ_c/2] and/or [σ_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:

$$\text{Max}[1.2 \cdot 7{,}800,\ \text{Min.}(13300,\ 4 \cdot 7{,}800)] = 13,\ 300 \text{ psi}$$

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 [$1^1/_4$Cr–$^1/_2$Mo-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:

$$t_{\text{req}} = \frac{PR_o}{SE + 0.4P} + CA$$

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 $^2\!/_3{*}S_y$ (for ferritic materials) and $S_{\text{UTS}}/3.5$ at temperature, T_i as shown as follows:

Condition No.	Operating Temperature, T_i, °F	Calculated Stress, σ_i, psi	$^2\!/_3{*}S_y$, psi	$S_{\text{UTS}}/3.5$, 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 $(S_y)_{@1{,}000°\text{F}}$ = 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 $^2\!/_3{*}S_y$ and $S_{\text{UTS}}/3.5$ 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) Temp$_1$ (°F): 1,000; Allowable Stress$_1$ (psi): 6,300
(b) Temp$_2$ (°F): T_{Di}; Calculated Stress$_2$ (psi): 4,402
(c) Temp$_3$ (°F): 1,050; Allowable Stress$_3$ (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:

$$\text{LMP}(t_{100{,}000},\ T_{Di})_i = \frac{\left(T_{Di} + 460\right)\left[C_{\text{LMP}} + \text{Log}_{10}\left(100{,}000\right)\right]}{1{,}000}$$

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.

$$t_{\text{req}} = \frac{PR_i}{SE - 0.6P} + CA = \frac{(45)(135)}{(14{,}800)(0.85) - 0.6(45)} + 0 = 0.484 \text{ in.}$$

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 $S_{\text{UTS}}/3.5$ at temperature, T_i.

Condition No.	Operating Temperature, T_i, °F	Calculated Stress, σ_i, psi	$\frac{2}{3}{*}S_y$, psi	$S_{\text{UTS}}/3.5$, 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 $S_{\text{UTS}}/3.5$ (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 $^2/_3 {}^* S_y$ (for ferritic materials) and $S_{UTS}/3.5$ at temperature T_i.

Condition No.	Operating Temperature, T_i, °F	Calculated Stress, σ_i, psi	$^2/_3 {}^* S_y$, 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 $^2/_3 {}^* S_y$, 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) Temp$_1$ (°F): 900; Allowable stress$_1$ (psi): 6,700
(b) Temp$_2$ (°F): T_{Di}; Calculated stress$_2$ (psi): 6,682
(c) Temp$_3$ (°F): 950; Allowable stress$_3$ (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:

$$\text{LMP}(t_{100{,}000}, T_{Di})_i = \frac{\left(T_{Di} + 460\right)\left[C_{\text{LMP}} + \text{Log}_{10}\left(100{,}000\right)\right]}{1{,}000}$$

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.

$$\left(t_{\text{all}}\right)_i = 10\text{exp}\left[\left(\frac{1{,}000 \cdot \text{LMP}_i}{T_i + 460}\right) - C_{\text{LMP}}\right]$$

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 [1¼Cr – ½Mo–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: σ = 35,171 psi; τ = 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, DTi, °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 ⅛ 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 $^2\!/_3{*}S_y$ (for ferritic materials) and $S_{UTS}/3.5$ at temperature, T_i.

Condition No.	Operating Temperature, T_i, °F	Calculated Stress, σ_i, psi	$^2\!/_3{*}S_y$, 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 $^2\!/_3{*}S_y$ 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 $^2\!/_3{*}S_y$ 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 $^2\!/_3{*}S_y$ 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 $^2\!/_3{*}S_y$ (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 $^2\!/_3{*}S_Y$ 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) $Temp_1$ (°F): 700; Allowable $Stress_1$ (psi): 18,100
(b) $Temp_2$ (°F): T_{Di}; Calculated $Stress_2$ (psi): 17,000
(c) $Temp_3$ (°F): 750; Allowable $Stress_3$ (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:

$$\mathrm{LMP}(t_{100,000}, T_{Di})_i = \frac{\left(T_{Di} + 460\right)\left[C_{\mathrm{LMP}} + \mathrm{Log}_{10}\left(100,000\right)\right]}{1,000}$$

With a C_{LMP} = 20.0 per Table 10B.2 of API 579-1/ASME FFS-1, the LMP for each condition is shown in Table A-3.

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 (see Table A-4).

$$\left(t_{\mathrm{all}}\right)_i = 10\exp\left[\left(\frac{1,000\cdot\mathrm{LMP}_i}{T_i + 460}\right) - C_{\mathrm{LMP}}\right]$$

Step 6. Compute the life fraction, λ_i, for each operating condition (see Table A-5):

$$\lambda_i = t_i/\left(t_{\mathrm{all}}\right)_i$$

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 × 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_i, °F	Calculated Stress, σ_i, psi	$^2/_3 * S_y$, 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		
	Girth flange		15,396	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_{Di},°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
	Girth flange		20.0	741	30.03
			20.0	949	35.23
			20.0	789	31.23
			20.0	726	29.65

Table A-4
Allowable Duration Values

Condition No.	Component	T_i, °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_i, °F	P_i, psig	T_i, 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

INTENTIONALLY LEFT BLANK

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 $^{3}/_{8}$ 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)

	Wall Thickness, in. (mm)								
Test Piece Per JIS Z 2241	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$^1/_4$Cr–1Mo	Forgings
SA-387	22	K21590	2$^1/_4$Cr–1Mo	Plate
SA-508	22	K21590	2$^1/_4$Cr–1Mo	Forgings
SA-336	F22V	K31835	2$^1/_4$Cr–1Mo–V	Forgings
SA-182	F22V	K31835	2$^1/_4$Cr–1Mo–V	Forgings
SA-541	22V	K31835	2$^1/_4$Cr–1Mo–V	Forgings
SA-542	D	K31835	2$^1/_4$Cr–1Mo–V	Plate
SA-832	22V	K31835	2$^1/_4$Cr–1Mo–V	Plate
SA-336	F3V	K31830	3Cr–1Mo–$^1/_4$V–Ti–B	Forgings
SA-832	21V	K31830	3Cr–1Mo–$^1/_4$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 $0.4 < S/a \le 1.0$ 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.

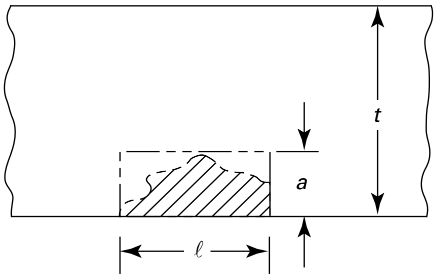
NOTE: (1) 4 in. (100 mm) ≤ t ≤ 12 in. (300 mm)

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

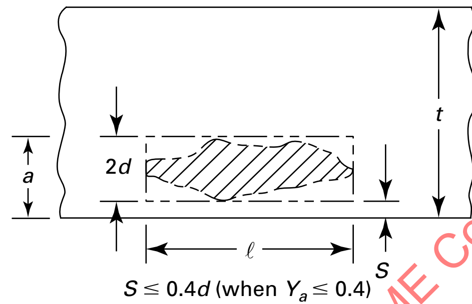
Flaw Aspect Ratio, a/ℓ	Subsurface Flaw, a/t
0.00	$0.015Y_a^{1.00}$
0.05	$0.017Y_a^{0.91}$
0.10	$0.019Y_a^{0.69}$
0.15	$0.021Y_a^{0.43}$
0.20	$0.025Y_a^{0.45}$
0.25	$0.028Y_a^{0.57}$
0.30	$0.033Y_a^{0.75}$
0.35	$0.038Y_a^{0.90}$
0.40	$0.043Y_a^{1.00}$
0.45	$0.049Y_a^{1.00}$
0.50	$0.056Y_a^{1.00}$

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 $0.4 < S/a \le 1.0$ 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.

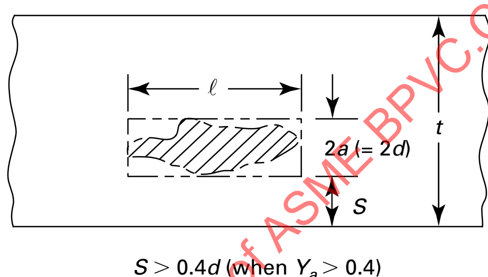
Figure 1
Alternative Flaw Classification of Single Indication



(a) Surface Indication [Note (1)]



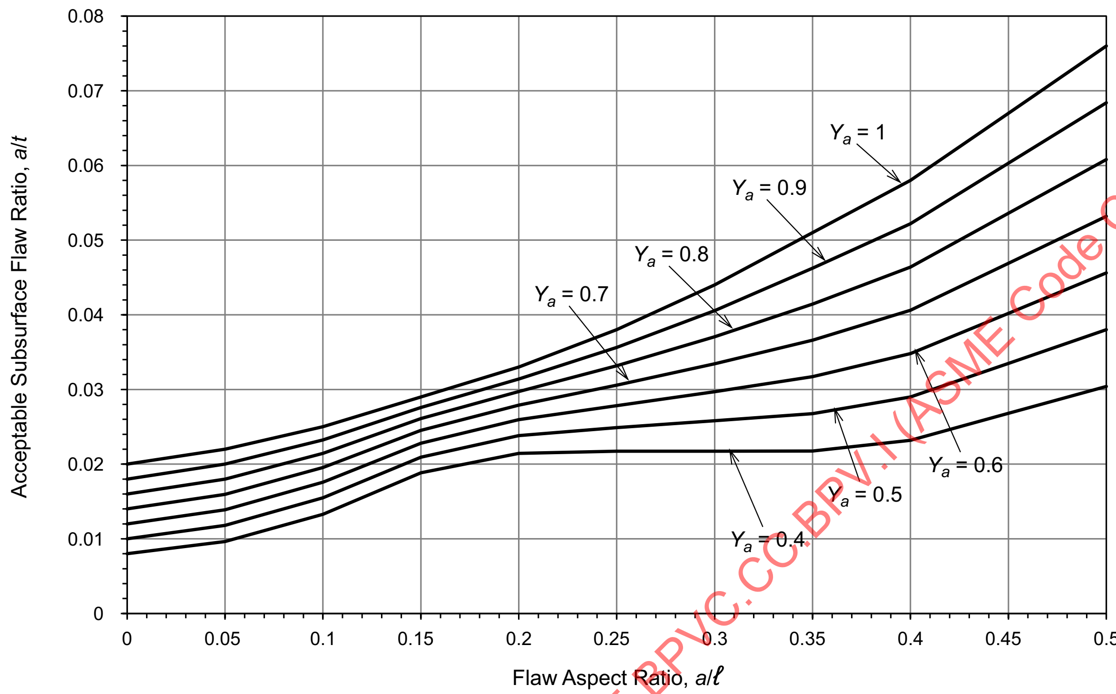
(b) Surface Indication [Note (1)]



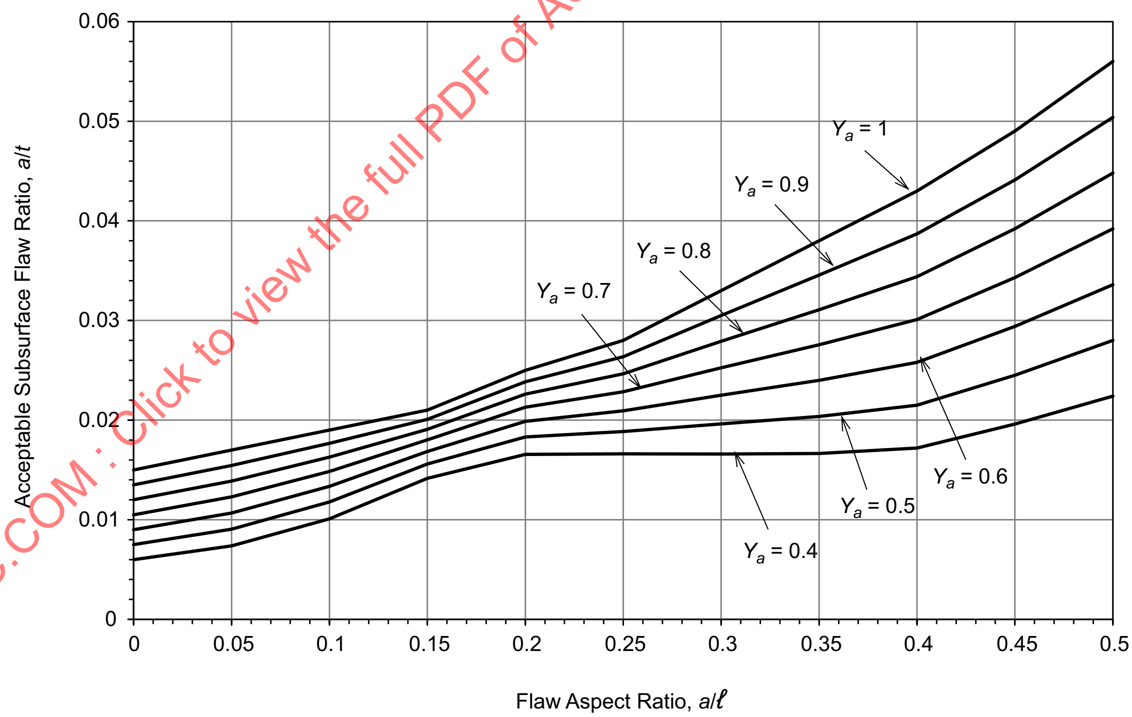
(c) Subsurface Indication

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) ≤ *t* ≤ 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) ≤ t ≤ 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.

INTENTIONALLY LEFT BLANK

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. (3 048 mm), an outside diameter not exceeding 72 in. (1 829 mm), and a thickness not exceeding 1 in. (25 mm).

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

INTENTIONALLY LEFT BLANK

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–½Mo	Forgings
	F2	K12122	½Cr–½Mo	Forgings
	F3V	K31830	3Cr–1Mo–¼V–Ti–B	Forgings
	F3VCb	K31390	3Cr–1Mo–¼V–Cb–Ca	Forgings
	F5	K41545	5Cr–½Mo	Forgings
	F5a	K42544	5Cr–½Mo	Forgings
	F9	K90941	9Cr–1Mo	Forgings
	F12, Cl 1	K11562	1Cr–½Mo	Forgings
	F12, Cl. 2	K11564	1Cr–½Mo	Forgings
	F11, Cl. 1	K11597	1¼Cr–½Mo–Si	Forgings
	F11, Cl. 2	K11572	1¼Cr–½Mo–Si	Forgings
	F21	K31545	3Cr–1Mo	Forgings
	F22, Cl. 1	K21590	2¼Cr–1Mo	Forgings
	F22, Cl. 3	K21590	2¼Cr–1Mo	Forgings
	F22V	K31835	2¼Cr–1Mo–¼V	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–½Mo	Seamless pipe
	P2	K11547	½Cr–½Mo	Seamless pipe
	P5	K41545	5Cr–½Mo	Seamless pipe
	P5b	K51545	5Cr–½Mo–Si	Seamless pipe
	P5c	K41245	5Cr–½Mo–Ti	Seamless pipe
	P9	K90941	9Cr–1Mo	Seamless pipe
	P11	K11597	1¼Cr–½Mo–Si	Seamless pipe
	P12	K11562	1Cr–½Mo	Seamless pipe
	P21	K31545	3Cr–1Mo	Seamless pipe
	P22	K21590	2¼Cr–1Mo	Seamless pipe
	P91	K90901	9Cr–1Mo–V	Seamless pipe
SA-336	F1	K11564	1Cr–½Mo	Forgings
	F3V	K31830	3Cr–1Mo–¼V–Ti–B	Forgings
	F3VCb	K31390	3Cr–1Mo–¼V–Cb–Ca	Forgings
	F5	K41545	5Cr–1Mo	Forgings
	F5A	K42544	5Cr–1Mo	Forgings
	F9	K90941	9Cr–1Mo	Forgings
	F11, Cl. 2	K11572	1¼Cr–½Mo–Si	Forgings
	F11, Cl. 3	K11572	1¼Cr–½Mo–Si	Forgings
	F12	K11564	1Cr–½Mo	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 ≤ 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) 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.
(c) $Y_a = S/d$, 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 ≤ 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.
(d) Linear interpolation is permissible for intermediate values of the flaw aspect ratio a/ℓ.
(e) 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.

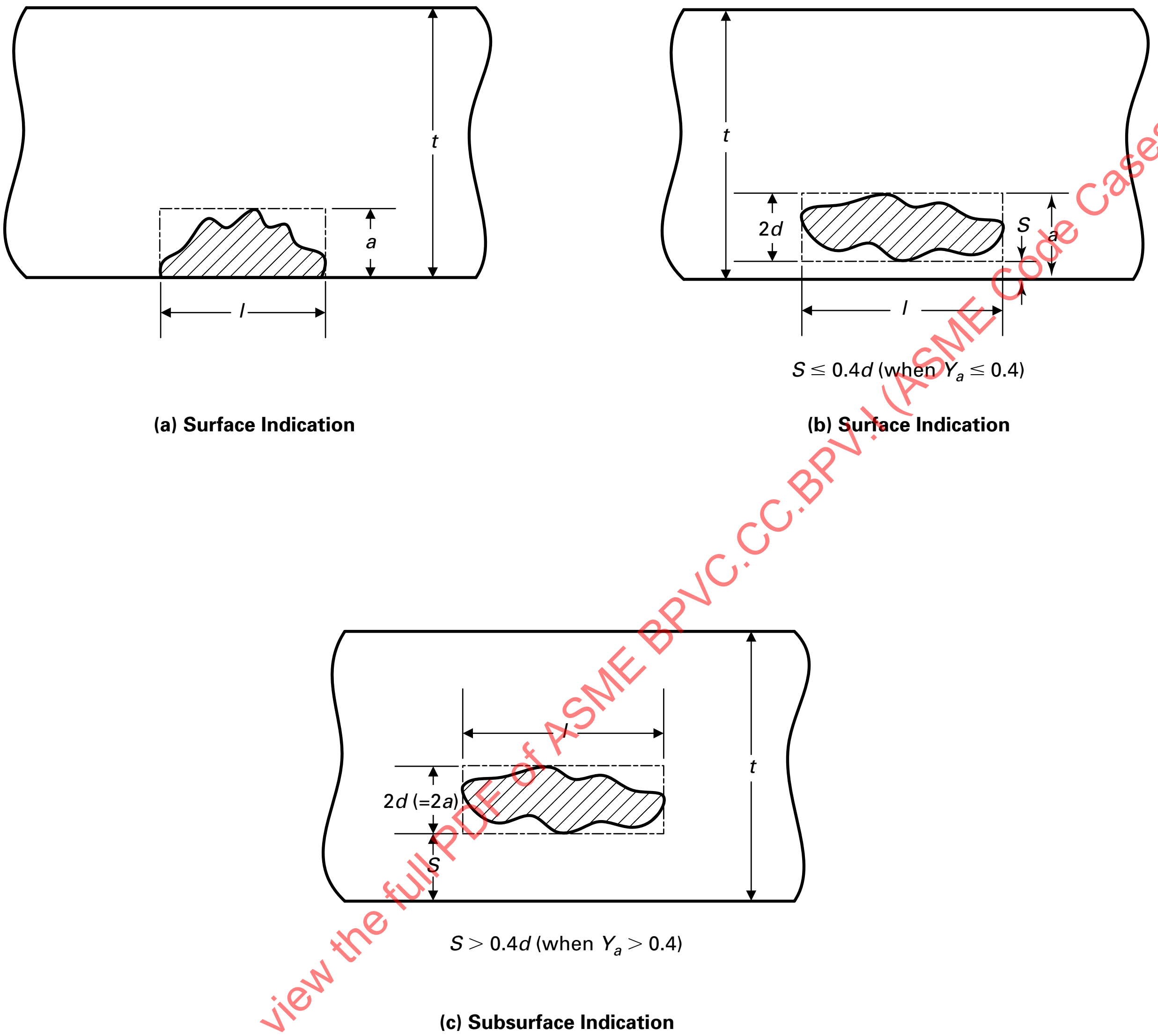
NOTE: (1) 100 mm (4 in.) ≤ t ≤ 300 mm (12 in.)

Table 3
Alternative Subsurface Flaw Acceptance Criteria for Welds With Thickness of 400 mm (16 in.) and With 0.4 < Y_a ≤ 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	$0.056Y_a^{1.00}$

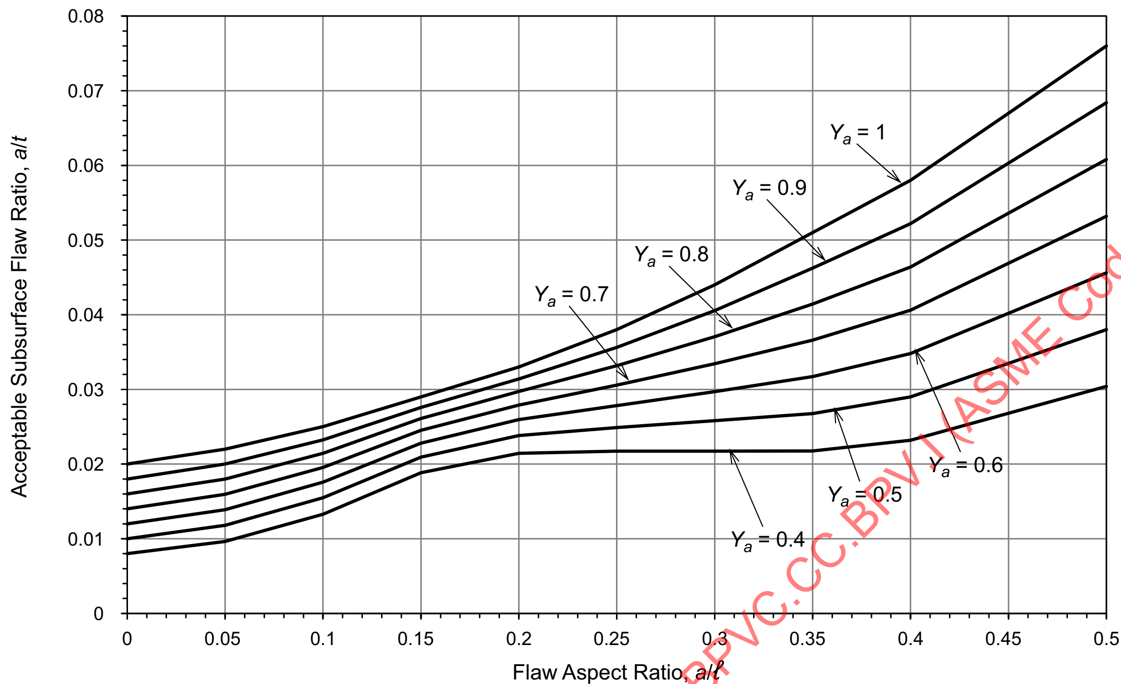
GENERAL NOTES:
(a) Use with Figure 1; see Figure 2, sketch (b).
(b) The parameter t is thickness of the weld excluding any allowable reinforcement, and the parameter ℓ is the length of the flaw. For a butt weld joining two members having different thickness at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet weld shall be included in t.
(c) $Y_a = S/d$, 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 ≤ 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.
(d) Linear interpolation is permissible for intermediate values of the flaw aspect ratio a/ℓ.
(e) When the weld thickness, t ≥ 400 mm (16 in.), the acceptance criteria for a thickness of 400 mm (16 in.) shall be applied.
(f) When 300 mm (12 in.) ≤ weld thickness, t < 400 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

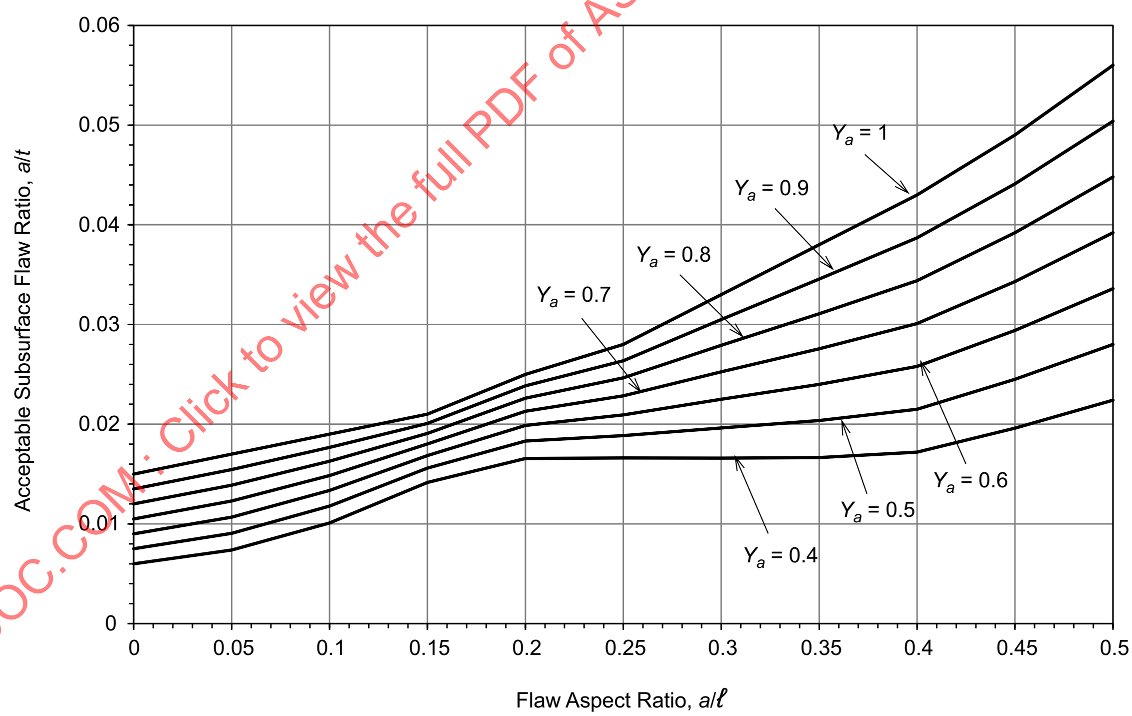


GENERAL NOTE: $Y_a = S/d$, where Y_a is the flaw-to-surface proximity factor.

Figure 2
Alternative Subsurface Flaw Acceptance Criteria



(a) For weld thickness 100 mm (4 in.) ≤ t ≤ 300 mm (12 in.) [Note (1)]



(b) For weld thickness t = 400 mm (16 in.) [Note (2)]

NOTES:
(1) This graph is obtained from acceptance criteria for subsurface flaw for 100 mm (4 in.) ≤ t ≤ 300 mm (12 in.) in Table 2.
(2) This graph is obtained from acceptance criteria for subsurface flaw for t = 400 mm (16 in.) in Table 3.

Case 2959-1
Laser Annealing of Nameplates

(25)

Section VIII, Division 1

ANNULLED

March 30, 2025

Reason: No longer needed.

INTENTIONALLY LEFT BLANK

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 $^3/_8$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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:

$$A = 0.125/(R_o/t) \tag{1}$$

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

$$D_F = 2.0 \tag{2}$$

(b) $1 < T \leq 100{,}000$ hr

$$D_F = \frac{2}{1 + 0.0288\ln(T)} \tag{3}$$

(c) $T > 100{,}000$ hr

$$D_F = 1.5 \tag{4}$$

* 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:

$$B = AE/D_F \tag{5}$$

$$B = S_c/D_F \tag{6}$$

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) $T \le 1.0$ hr

$$D_F = 3.0 \tag{7}$$

(b) $1 < T \le 100{,}000$ hr

$$D_F = \frac{3}{1 + 0.0434 \ln(T)} \tag{8}$$

(c) $T > 100{,}000$ hr

$$D_F = 2.0 \tag{9}$$

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:

$$P = \frac{2AE}{(D_F)(D_o/t)} \tag{10}$$

$$P = \frac{2S_c}{(D_F)(D_o/t)} \tag{11}$$

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:

$$A \approx \frac{0.125}{(R_o/t)} \tag{12}$$

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) $T \le 1.0$ hr

$$D_F = 4.0 \tag{13}$$

(b) $1 < T \le 100{,}000$ hr

$$D_F = \frac{4}{1 + 0.0869 \ln(T)} \tag{14}$$

(c) $T > 100{,}000$ hr

$$D_F = 2.0 \tag{15}$$

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:

$$P = \frac{0.25E}{\left(D_F\right)(R_o/t)^2} \tag{16}$$

$$P = \frac{2S_c}{(D_F)(R_o/t)} \tag{17}$$

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:

$$A = \pi^2/(\Gamma L/r)^2 \tag{18}$$

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) $0 < (\Gamma L/r) < 120$

$$D_F = \left(2.78 \times 10^{-5}\right)(\Gamma L/r)^2 + 1.5 \quad (19)$$

(b) $(\Gamma L/r) \geq 120$

$$D_F = 1.90 \quad (20)$$

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.

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)

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.

$$\varepsilon_t = \varepsilon_e + \varepsilon_p + \varepsilon_c \tag{I-1}$$

(2) The elastic strain is defined as follows:

$$\varepsilon_e = \frac{\sigma}{E_y} \tag{I-2}$$

(3) The plastic strain is expressed as follows:

$$\varepsilon_p = \gamma_1 + \gamma_2 \tag{I-3}$$

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:

$$\varepsilon_c = -\,(1/\Omega)\ln(1 - \dot{\varepsilon}_{co}\Omega T) \tag{I-6}$$

where

$$\log_{10}(\dot{\varepsilon}_{co}) = -\left[A_o + \Delta_{\Omega}^{sr} + \frac{A_1 + A_2 S_1 + A_3 S_1^2 + A_4 S_1^3}{T_r + T_e}\right] \tag{I-7}$$

$$\log_{10}(\Omega) = B_o + \Delta_{\Omega}^{cd} + \frac{B_1 + B_2 S_1 + B_3 S_1^2 + B_4 S_1^3}{T_r + T_e} \tag{I-8}$$

$$S_1 = \log_{10}(\sigma) \tag{I-9}$$

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:

$$E_t = \frac{1}{d\varepsilon_e/d\sigma + d\varepsilon_p/d\sigma + d\varepsilon_c/d\sigma}$$
$$E_t = \frac{1}{H_1 + (H_2 + H_3) + H_4} \tag{I-10}$$

Step 2. Calculate H_1 due to the elastic component of strain.

$$H_1 = 1/E \tag{I-11}$$

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)

$$H_2 = (2\alpha_2\alpha_6\sigma_t)^{-1}\left\{\left(\frac{\sigma_t}{\alpha_3}\right)^{1/\alpha_2}\left[\tanh\left(\frac{2\alpha_5 - 2\sigma_t}{\alpha_6}\right) + 1\right]\left[\alpha_6 - 2\alpha_2\sigma_t + 2\alpha_2\sigma_t \tanh\left(\frac{2\alpha_5 - 2\sigma_t}{\alpha_6}\right)\right]\right\} \tag{I-12}$$

$$H_3 = (-2\alpha_6\alpha_7\sigma_t)^{-1}\left\{\left(\frac{\sigma_t}{\alpha_8}\right)^{1/\alpha_7}\left[\tanh\left(\frac{2\alpha_5 - 2\sigma_t}{\alpha_6}\right) - 1\right]\left[\alpha_6 + 2\alpha_7\sigma_t + 2\alpha_7\sigma_t \tanh\left(\frac{2\alpha_5 - 2\sigma_t}{\alpha_6}\right)\right]\right\} \tag{I-13}$$

where

$$\alpha_1 = R = \sigma_{ys}/\sigma_{\text{ult}} \tag{I-14}$$

$$\alpha_2 = m_1 = \frac{\ln(R) + (\varepsilon_p' - \varepsilon_{ys})}{\ln\left[\frac{\ln(1 + \varepsilon_p')}{\ln(1 + \varepsilon_{ys})}\right]} \tag{I-15}$$

$$\alpha_3 = A_1 = \frac{\sigma_{ys}(1 + \varepsilon_{ys})}{\ln(1 + \varepsilon_{ys})^{m_1}} \tag{I-16}$$

$$\alpha_4 = K = 1.5R^{1.5} - 0.5R^{2.5} - R^{3.5} \tag{I-17}$$

$$\alpha_5 = \sigma_{ys} + K(\sigma_{\text{ult}} - \sigma_{ys}) \tag{I-18}$$

$$\alpha_6 = K(\sigma_{\text{ult}} - \sigma_{ys}) \tag{I-19}$$

$$\alpha_7 = m_2 \tag{I-20}$$

$$\alpha_8 = A_2 = \sigma_{uts}\, e^{m_2}/\left(m_2^{\,m_2}\right) \tag{I-21}$$

$$\sigma_t = (1 + \varepsilon_{es})\sigma_{es} \tag{I-22}$$

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.

$$H_4 = C_{10}/C_7 + C_8/K_1 \tag{I-23}$$

where

$$A_{00} = A_0 + \Delta_{\Omega}^{sr} \tag{I-24}$$

$$B_{00} = B_0 + \Delta_{\Omega}^{cd} \tag{I-25}$$

$$K_1 = T_r + T_e \tag{I-26}$$

$$S_1 = \log_{10}(0.8\sigma) \tag{I-27}$$

$$C_1 = B_{00} + \left(B_1 + B_2 S_1 + B_3 S_1^2 + B_4 S_1^3\right)/K_1 \tag{I-28}$$

$$C_2 = A_{00} + \left(A_1 + A_2 S_1 + A_3 S_1^2 + A_4 S_1^3\right)/K_1 \tag{I-29}$$

$$C_3 = B_2 + 2B_3 S_1 + 3B_4 S_1^2 \tag{I-30}$$

$$C_4 = A_2 + 2A_3 S_1 + 3A_4 S_1^2 \tag{I-31}$$

$$C_5 = 10^{c_1}\left(1/10^{c_2}\right)T\,C_3 \ln(10) \quad \text{(I-32)}$$

$$C_6 = \ln(10)\ln\left[1 - 10^{c_1}\left(1/10^{c_2}\right)T\right] \quad \text{(I-33)}$$

$$C_7 = 10^{c_1}\left(1/10^{c_2}\right)T - 1 \quad \text{(I-34)}$$

$$C_8 = \left(1/10^{c_1}\right)C_6 C_4 \quad \text{(I-35)}$$

$$C_9 = C_5/K_1 - \left[10^{c_1}\left(1/10^{c_2}\right)TC_4 \ln(10)\right]/K_1 \quad \text{(I-36)}$$

$$C_{10} = \left(1/10^{c_1}\right)C_9 \quad \text{(I-37)}$$

Step 5. Calculate tangent modulus, E_t, for various stress values from the following equation:

$$E_t = 1/\left(H_1 + H_2 + H_3 + H_4\right) \quad \text{(I-38)}$$

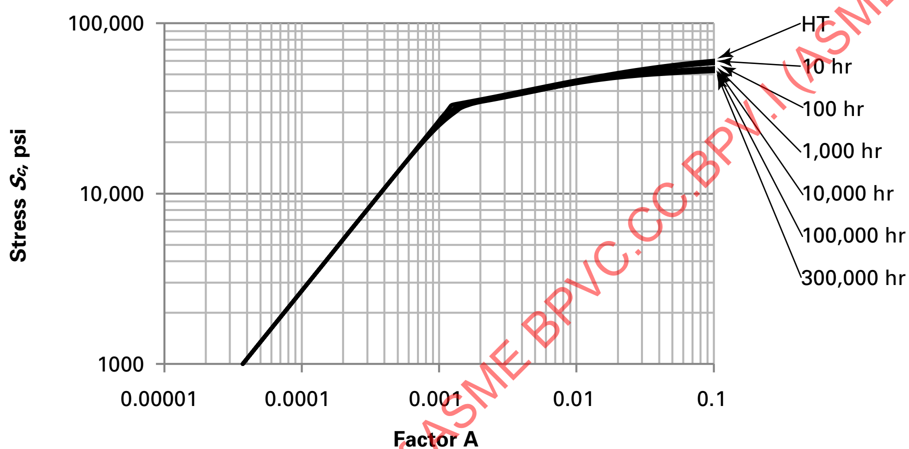
Step 6. Determine Factor A for various σ values from the following equation:

$$A = \sigma/E_t = S_c/E_t \quad \text{(I-39)}$$

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

Figure II-1
External Pressure Chart at 800°F for 9Cr–1Mo–V



GENERAL NOTES:
(a) E = 26.9 E+06 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
a	AE	33,307.03
b	0	−944.62672
c	0	−27,477,658
d	0	−137,186.88
e	0	−7.4842193 E+09
f	0	−1,625,136.10
g	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
a	AE	3,392.3225	27,526.50
b	0	−526.13853	317.49751
c	0	10,856,749	14,361,808
d	0	477,037.25	10,024.23
e	0	1.038271 E+10	6.440318 E+08
f	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
a	AE	−1,200	27,008.733
b	0	−268.58213	256.8332
c	0	32,461,668	12,235,600
d	0	−27,817.381	5,473.2533
e	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
a	AE	3,432.3766	27,900
b	0	−627.91172	259.10676
c	0	11,859,512	11,883,652
d	0	562,516.77	6,789.5914
e	0	6.900575 E+09	4.391358 E+08
f	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
a	AE	−2,100	27,350
b	0	−246.16678	167.89938
c	0	35,346,632	8,818,383.3
d	0	−95,177.428	2,742.4627
e	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
a	AE	−700	26,600
b	0	−53.625149	182.45175
c	0	28,655,071	9,751,975.4
d	0	158,460.14	1,635.0183
e	0	0	9.362225 E+07

Table II-1.1
Equation of A Versus S_c at 800°F (Cont'd)

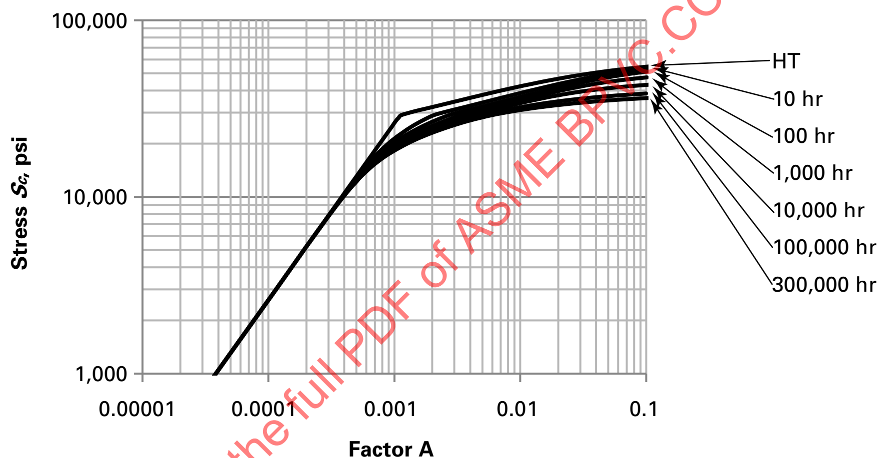
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	A <0.000523	0.000523 < A <0.00144	0.00144 < A <0.1
a	AE	−625	26,231.115
b	0	−88.222411	220.27866
c	0	28,301,340	11,531,034
d	0	181,705.18	524.15689
e	0	0	29,922,776

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

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
a	*AE*	27,964.167	31,327.386
b	0	−1,093.6821	102.34923
c	0	−26,012,815	5,281,452
d	0	−116,800.63	973.22158
e	0	−7.7168820 E+09	5.8469333 E+07
f	0	8,479,773.40	0
g	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**
a	*AE*	−5,435.0786	27,485.33
b	0	1,439.5077	101.64159
c	0	57,848,105	4,756,057.2
d	0	−59,411.001	1,455.434
e	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**
a	*AE*	−9,150	27,800
b	0	2,031.3851	57.948237
c	0	70,911,205	2,979,758
d	0	−22,947.027	365.2436
e	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**
a	*AE*	−4,950	25,000
b	0	1,650.2558	67.781989
c	0	56,348,889	3,429,321.2
d	0	−23,663.358	−2.7483014
e	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**
a	*AE*	−4,625.6955	20,479.985
b	0	1,838.9162	139.23122
c	0	55,864,317	5,976,308
d	0	68,472.463	632.11783
e	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**
a	*AE*	−4,800	17,944.433
b	0	2,170.7464	278.66649
c	0	57,392,294	10,056,596
d	0	260,922.72	3,926.4111
e	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**
a	*AE*	−4,390	17,996.056
b	0	2,118.9741	352.2657
c	0	56,354,875	11,757,555

Table II-2.1
Equation of A Versus S_c at 900°F (Cont'd)

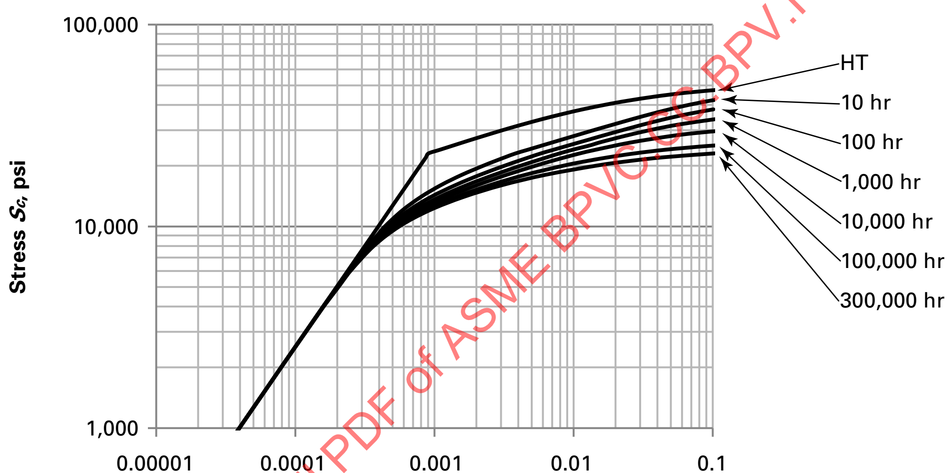
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	A < 0.00023	0.00023 < A < 0.0086	0.0086 < A < 0.1
d	0	242,642.88	6,786.9067
e	0	8.836059 E+09	2.58 E+08

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
a	*AE*	15,600	24,677.21
b	0	762.67756	150.47277
c	0	24,665,999	6,555,769
d	0	49,064.031	2,035.3028
e	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
a	*AE*	−1415.0514	21,582.144
b	0	1,813.0367	36.417634
c	0	42,500,284	1,675,388.9
d	0	59,994.423	66.978226
e	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
a	*AE*	−3,028.8724	−17,901.869
b	0	3,040.0306	48.196408
c	0	54,298,553	2,047,594.8
d	0	301,719.7	−475.20663
e	0	1.035902 E+10	−1.676553 E+07
f	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
a	*AE*	−2,762.6546	19,873.546
b	0	3,415.3795	−73.002048
c	0	54,970,975	−701,480.94
d	0	386,549.9	−4,563.0882
e	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
a	*AE*	−4,100	15,488.498
b	0	4,389.4521	108.58297
c	0	65,950,953	3,056,392.6
d	0	574,934.53	1,162.6443
e	0	1.630781 E+10	3.733611 E+07
f	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
a	*AE*	−3,300	12,255.784
b	0	3,927.0281	260.45285
c	0	61,252,738	5,792,090.9
d	0	180,367.13	5,894.3349
e	0	6.843272 E+09	1.568939 E+08
f	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
a	*AE*	−4,150	9,985.1055
b	0	4,931.0826	446.16032

Table II-3.1
Equation of A Versus S_c at 1,000°F (Cont'd)

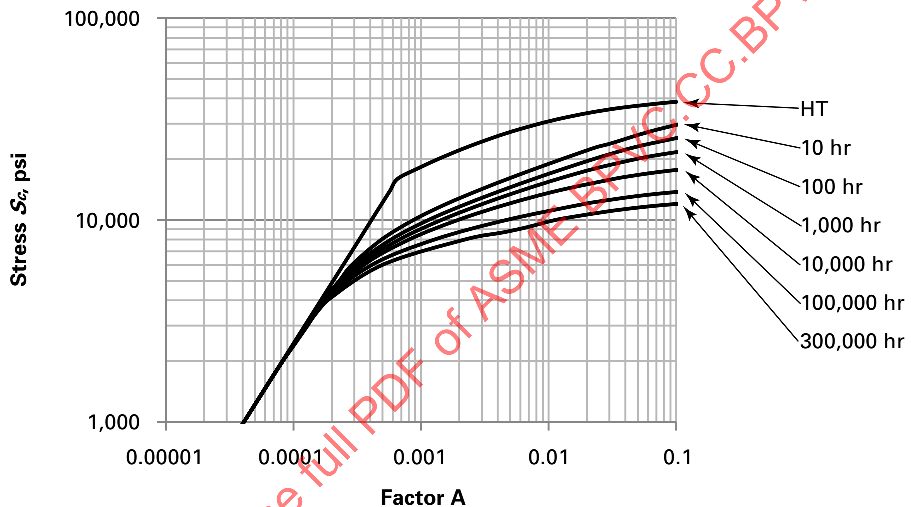
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	A <0.000159	0.000159 < A < 0.00305	0.00305 < A < 0.1
c	0	68,833,229	8,771,715.2
d	0	860,066.2	13,996.708
e	0	1.925057 E+10	3.376168 E+08

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	...	...	...	...

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
a	AE	8,108.2914
b	0	1,181.5642
c	0	29,235,051
d	0	136,007.9
e	0	4.9706220 E+09
f	0	1,598,683.60
g	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
a	AE	−1,140	18,200
b	0	3,536.0981	9.3141382
c	0	43,404,767	425,372.13
d	0	353,872.23	11.181658
e	0	9.033107 E+09	0
f	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
a	AE	−1290	11,787.381
b	0	4,608.8078	40.525951
c	0	48,472,367	1,226,276.9
d	0	551,752.87	−273.5062
e	0	1.227712 E+10	−7.548069 E+06
f	0	−1,113,258.7	0

Corresponding Variables in Equation [Note (1)]	1,000 hr	
	A < 0.0001057	0.0001057 < A < 0.1
a	AE	−495.88388
b	0	3,559.1794
c	0	37,590,499
d	0	432,774.92
e	0	8.059657 E+09
f	0	5,861,803.8
g	0	1.450160 E+11
h	0	163,854.14

Corresponding Variables in Equation [Note (1)]	10,000 hr	
	A < 0.000041	0.000041 < A < 0.1
a	AE	−432.0064
b	0	4,256.832
c	0	40,051,096
d	0	773,433.38
e	0	1.161357 E+10
f	0	15,199,847
g	0	2.933055 E+11
h	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
a	AE	−1,420	1,343.2247
b	0	6,049.6909	2,373.7664

Table II-4.1
Equation of A Versus S_c at 1,100°F (Cont'd)

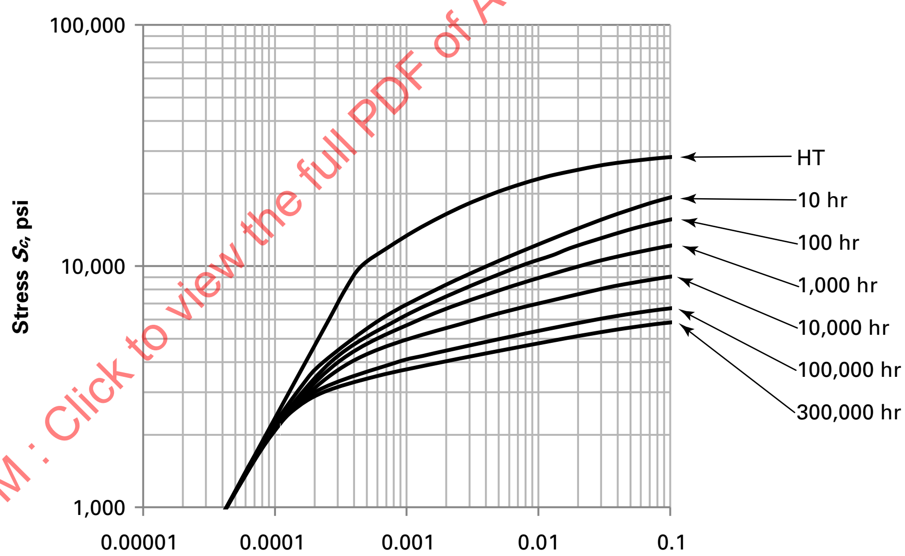
Corresponding Variables in Equation [Note (1)]	100,000 hr		
	A < 0.0000825	0.0000825 < A < 0.00464	0.00464 < A < 0.1
c	0	53,838,612	22,982,321
d	0	−196,668.59	127,135.51
e	0	0	1.878808 E+09
f	0	0	−910342.26
g	0	0	−1.257566 E+10
h	0	0	186,560.41
Corresponding Variables in Equation [Note (1)]	**300,000 hr**		
	A < 0.0000825	**0.0000825 < A < 0.00445**	**0.00445 < A < 0.1**
a	AE	−750	6,500
b	0	5,072.3258	117.41846
c	0	44,002,971	1,445,804
d	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

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		
	$A < 0.000342$	$0.000342 < A < 0.00585$	$0.00585 < A < 0.1$
a	*AE*	8,100	12,457.938
b	0	−3,260.2561	249.81876
c	0	−13,843,026	6,466,029
d	0	−2,297,378.1	4,726.8606
e	0	−5.5006489 E+10	1.4140819 E+08
e	0	17,904,079.00	0

Corresponding Variables in Equation [Note (1)]	10 hr		
	$A < 0.0000884$	$0.0000884 < A < 0.00894$	$0.00894 < A < 0.1$
a	*AE*	−190	7,817.0975
b	0	4,703.564	94.991391
c	0	34,418,600	1,512,340.8
d	0	556,197.69	877.80329
e	0	9.291228 E+09	2.122387 E+07

Corresponding Variables in Equation [Note (1)]	100 hr		
	$A < 0.000043$	$0.000043 < A < 0.0128$	$0.0128 < A < 0.1$
a	*AE*	−570	7,000
b	0	7,324.9089	58.082716
c	0	43,484,968	951,695.33
d	0	1,333,230.5	−24.590471
e	0	1.763429 E+10	0

Corresponding Variables in Equation [Note (1)]	1,000 hr	
	$A < 0.000043$	$0.000043 < A < 0.1$
a	*AE*	−500
b	0	7,544.3848
c	0	42,054,198
d	0	1,828,837.5
e	0	1.740295E+10
f	0	33,787,651
g	0	4.614434 E+11
h	0	−1,460,099.5

Corresponding Variables in Equation [Note (1)]	10,000 hr	
	$A < 0.0000431$	$0.0000431 < A < 0.1$
a	*AE*	−600
b	0	8,971.9687
c	0	45,912,539
d	0	1,631,820.9
e	0	1.236319E +10
f	0	27,426,260
g	0	2.752643 E+11

Corresponding Variables in Equation [Note (1)]	100,000 hr		
	$A < 0.0000431$	$0.0000431 < A < 0.00517$	$0.00517 < A < 0.1$
a	*AE*	−1500	4,056.906
b	0	19,240.074	185.68946
c	0	76,754,201	1,073,409.9
d	0	4,414,689.6	3,151.3673
e	0	2.56 E+10	2.300751 E+07
f	0	−16,737,525	0

Table II-5.1
Equation of A Versus S_c at 1,200°F (Cont'd)

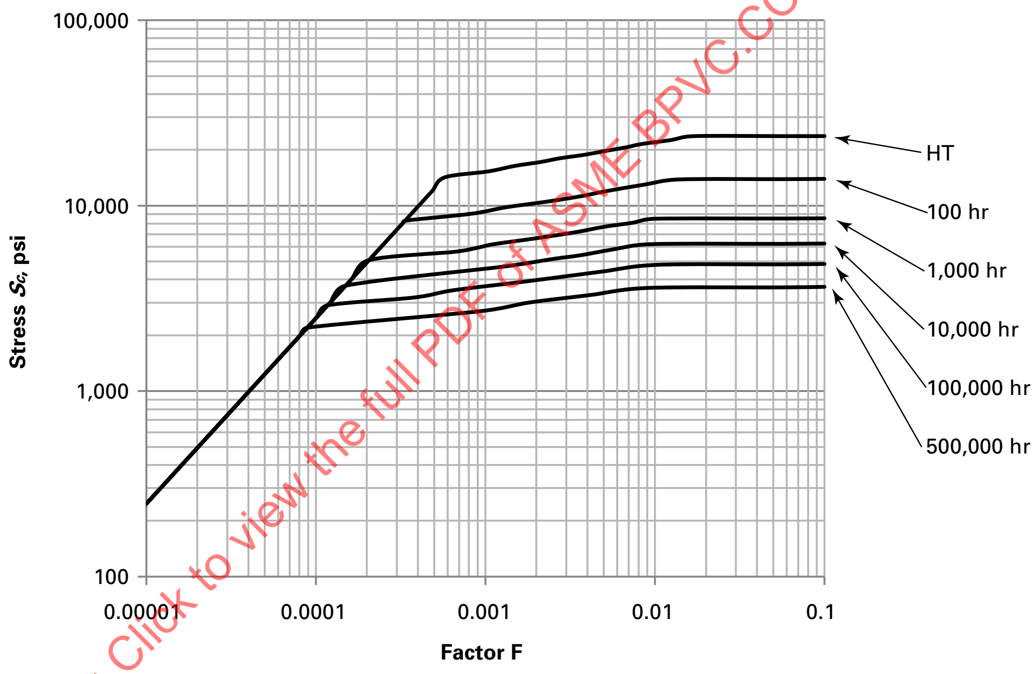
Corresponding Variables in Equation [Note (1)]	300,000 hr		
	A <0.0000431	0.0000431 < A < 0.0154	0.0154 < A < 0.1
a	AE	−1,500	4,242.3335
b	0	20,878.68	41.574097
c	0	78,628,243	257,062.1
d	0	2,520,802.6	−2.9844765
e	0	1.430431 E+10	0

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

Table II-6.1
Equation of A Versus S_c at 700°F to 1,000°F

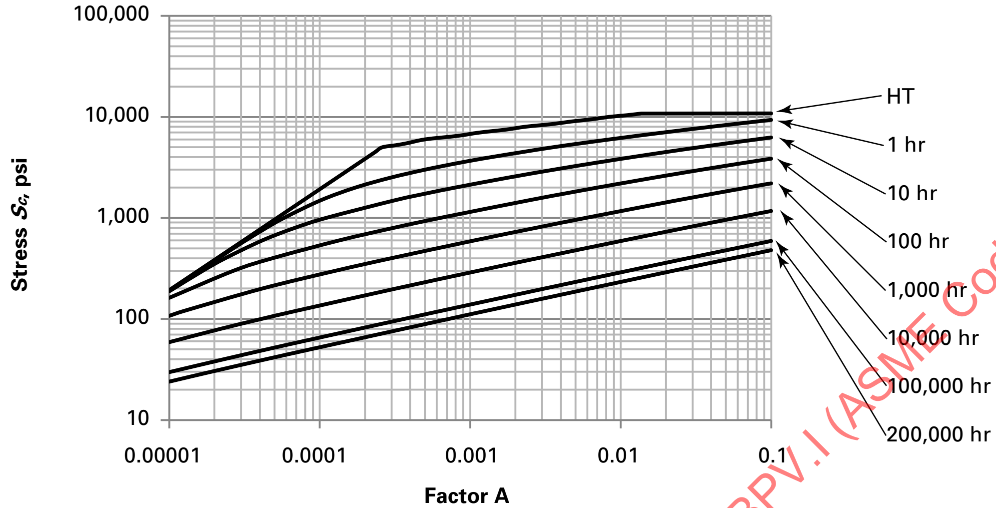
Corresponding Variables in Equation [Note (1)]	Hot Tensile		
	A < 0.000575	0.000575 < A < 0.0167	0.0167 < A < 0.1
a	AE	12,600	23,696.019
b	0	283.09278	0
c	0	6,838,889	240.09039
d	0	−1,304.9604	0
Corresponding Variables in Equation [Note (1)]	**100 hr**		
	A < 0.000336	0.000336 < A < 0.0138	0.0138 < A < 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
a	0.59597055	4,500	10,796.376
b	−6.2383167	514.63261	0
c	19,214,406	5,423,194.7	336.25171
d	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
a	−12.00	1,835.7091	4,591.6251
b	17,336.741	834.43502	45.646867
c	20,274,034	4,847,478.8	438,886.74
d	1.12 E+08	−12,674.375	−37.500831
e	3.63 E+11	0	0
f	−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
a	−20.00	2,085.00
b	17,909.152	125.803
c	23,755,443	617,777.08
d	13,990,058	729.50851
e	4.56 E+10	6,679,716.6
f	−4.69 E+08	0

Corresponding Variables in Equation [Note (1)]	100 hr	
	1 E−05 < *A* < 0.0043	0.0043 < *A* < 0.1
a	52.00	1,089.9066
b	21,531.635	145.72658
c	14,303,795	389,619.09
d	16,113,004	1,348.4801
e	2.96 E+10	6,977,939.1
f	−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
a	64.00	609.04204
b	17,174.104	88.891517
c	6,123,479.9	150,412.17
d	9,649,111.6	218.42662
e	9.99 E+09	1,173,137.9
f	−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
a	41.100542	435.00
b	16,309.263	14.829784
c	2,900,078.8	24,672.354
d	7,592,852.1	0
e	4.19 E+09	0
f	−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
a	18.894906	160.00
b	2.886437 E+04	22.430776
c	1.92 E+06	17,529.347
d	3.48 E+07	0
e	6.67 E+09	0
f	−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**
a	14.799303	97.00
b	33,280.766	57.120436
c	1,681,286.4	2,5474.34
d	49,879,803	−119.29564
e	7.05 E+09	0
f	−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, $\dot{\varepsilon}_{co}$		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, $\dot{\varepsilon}_{co}$		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 streel 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 $t_{c,\min} \le t_r \le t_c$

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 $s \le 2S$, 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.

INTENTIONALLY LEFT BLANK

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 $^1/_4$ in. (6 mm) nominal diameter, and the maximum size shall not exceed $^7/_8$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 × 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, *m*	Intercept, *b*
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	*R*	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

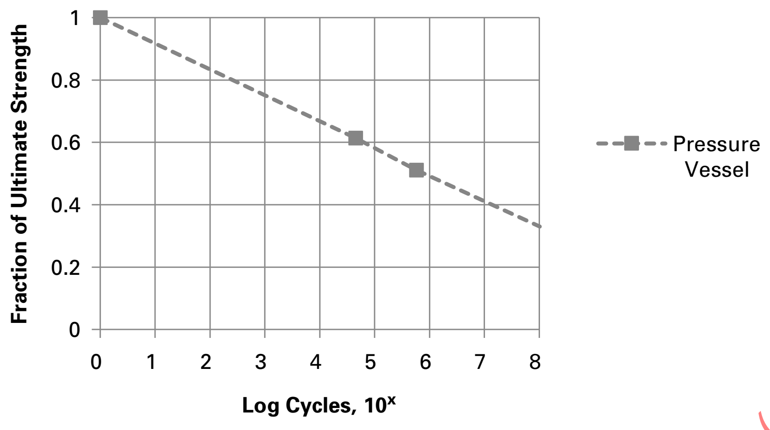
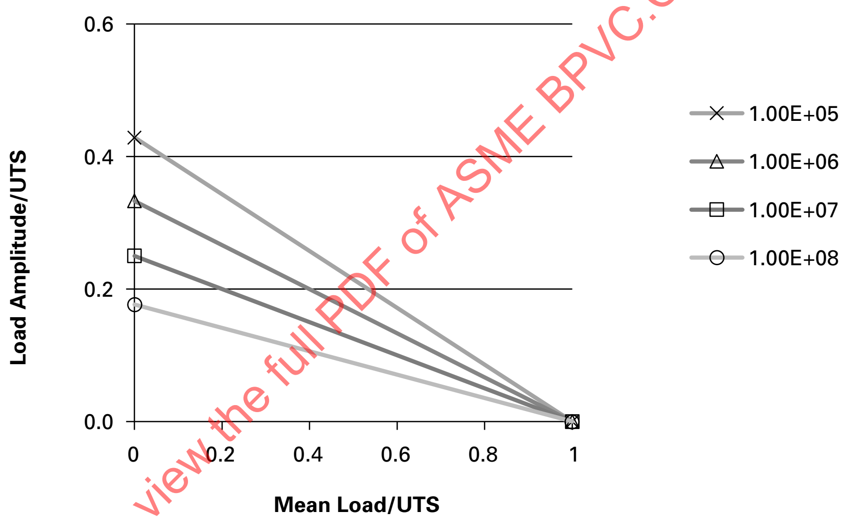


Figure 2
Goodman Type Constant Life Diagram



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

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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 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 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 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 $^1/_8$ 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.

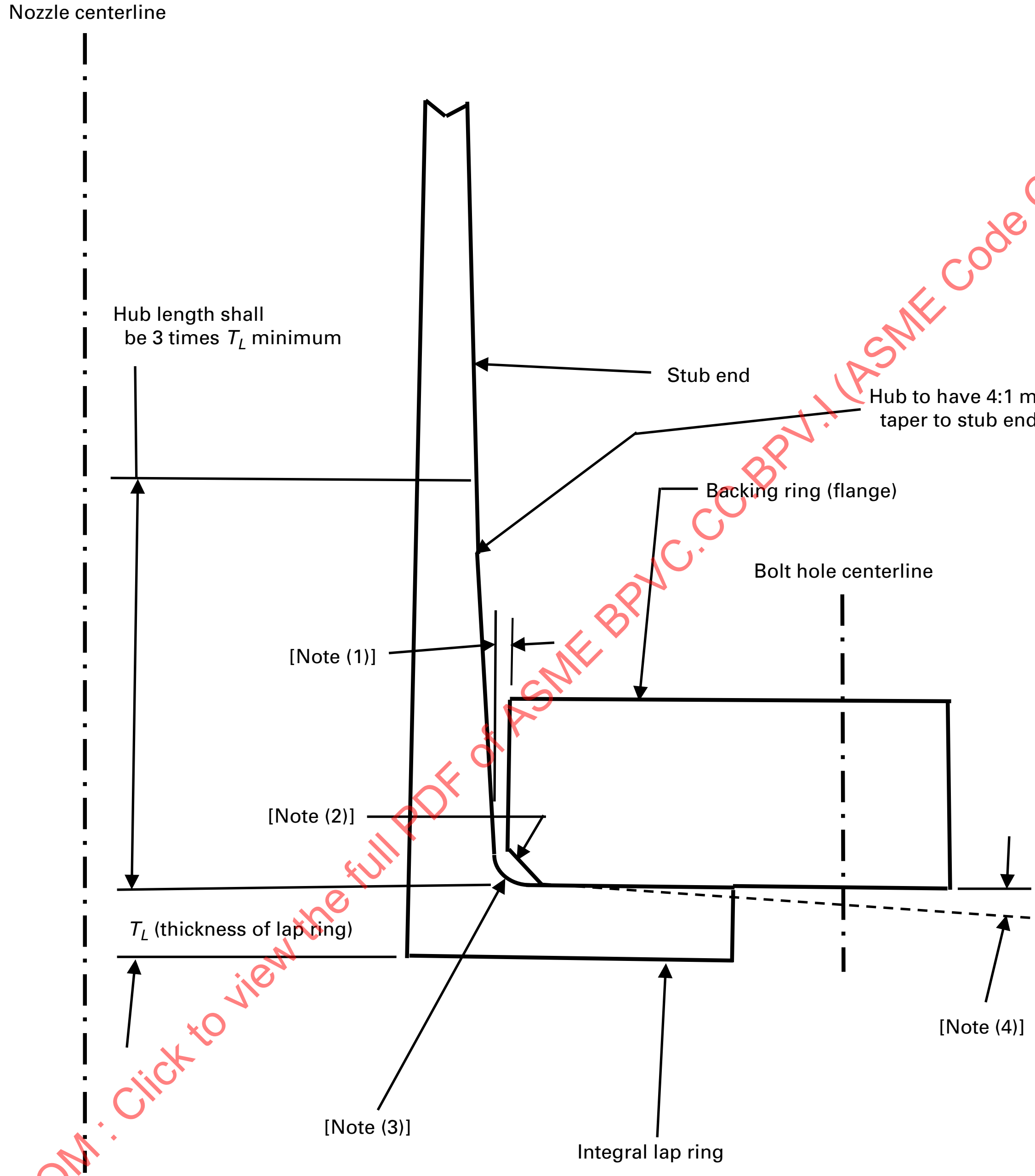
(o) The bearing stress between the backing ring and the back surface of the end lap shall not exceed 5,000 psi (34.5 MPa).

(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 $^1/_{16}$ in. (1.5 mm) radially of the backing ring bolt hole opening on nozzles up to 26 in. (406 mm) and within $^1/_8$ 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 ⅛ in. (3 mm); see (k).
(4) Maximum rotation of backing ring is limited; see (m).

INTENTIONALLY LEFT BLANK

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 Specification 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.

INTENTIONALLY LEFT BLANK

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)

	Wall Thickness, in. (mm)							
Test Piece Per JIS Z 2241:2011 Austenitic Pipes	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 outsider diameter $D \le 2$ 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.

INTENTIONALLY LEFT BLANK

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.

INTENTIONALLY LEFT BLANK

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/cm^3).

(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.

* Corrected by errata, ASME BPVC.CC-2025, July 2025.

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)

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 66⅔% 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 66⅔% 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 $66\frac{2}{3}$% 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 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 $66\frac{2}{3}$% 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 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 66⅔% 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 66⅔% 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.

(E)

Table 7
Yield Strength, *Y*–1, and Tensile Strength, *U*, Values

For Metal Temperature Not Exceeding, °F	Seamless Tube; Sheet, Strip, and Plate <0.25 in. Yield Strength Values, ksi [Note (1)]	Seamless Tube; Sheet, Strip, and Plate <0.25 in. Tensile Strength Values, ksi [Note (2)]	Seamless Pipe Yield Strength Values, ksi	Seamless Pipe Tensile Strength Values, ksi [Note (1)]	Plate ≥0.25 in. and Bar Yield Strength Values, ksi [Note (1)]	Plate ≥0.25 in. and Bar 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).

(E)

Table 7M
Yield Strength, *Y*–1, and Tensile Strength, *U*, Values

For Metal Temperature Not Exceeding, °C	Seamless Tube; Sheet, Strip, and Plate <6.35 mm Yield Strength Values, MPa [Note (1)]	Seamless Tube; Sheet, Strip, and Plate <6.35 mm Tensile Strength Values, MPa [Note (2)]	Seamless Pipe Yield Strength Values, MPa	Seamless Pipe Tensile Strength Values, MPa [Note (1)]	Plate ≥6.35 mm and Bar Yield Strength Values, MPa [Note (1)]	Plate ≥6.35 mm and Bar 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

INTENTIONALLY LEFT BLANK

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 66⅔% 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 66⅔% 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.