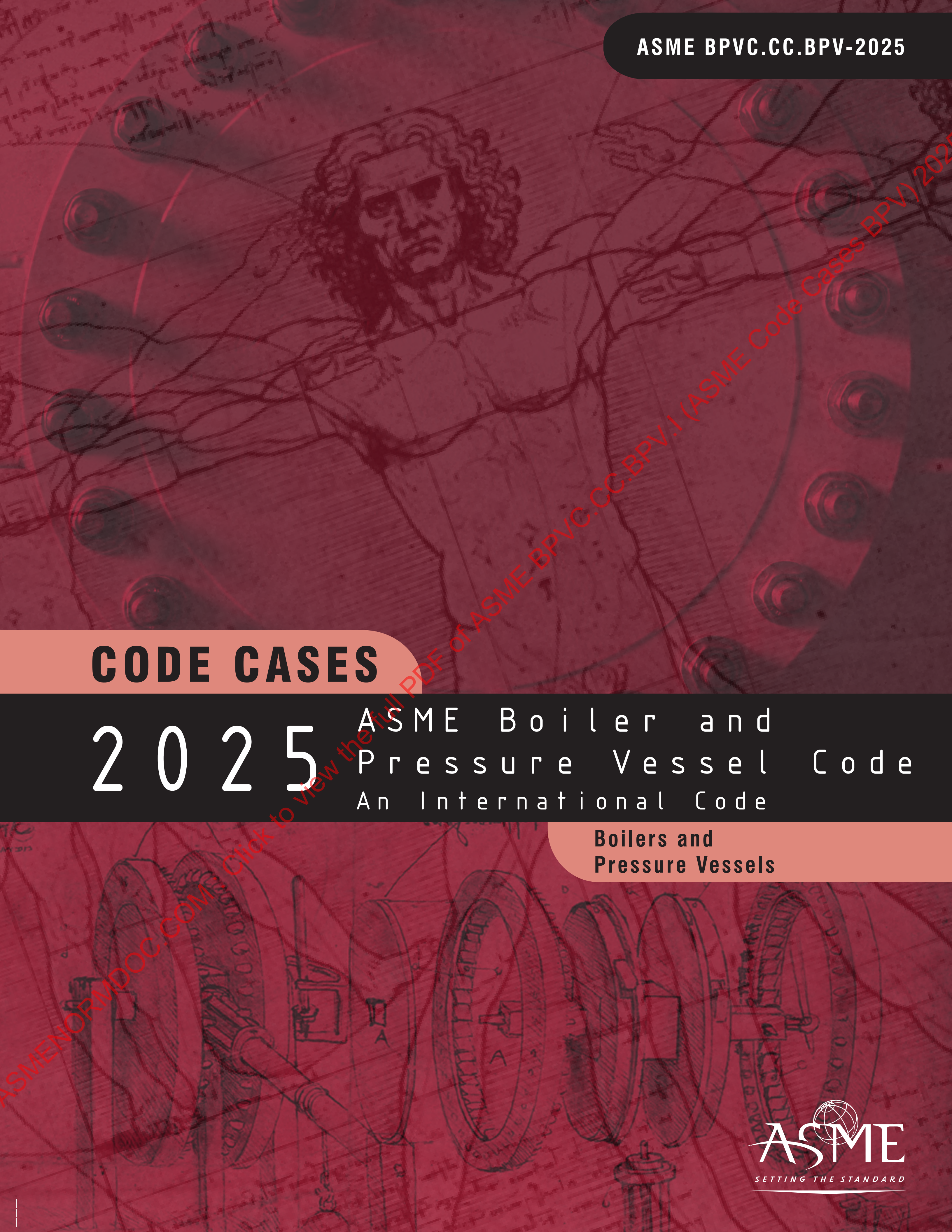

ASME BPVC.CC.BPV-2025

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

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FOREWORD*

(25)

In 1911, The American Society of Mechanical Engineers established the Boiler and Pressure Vessel Committee to formulate standard rules for the construction of steam boilers and other pressure vessels. In 2009, the Boiler and Pressure Vessel Committee was superseded by the following committees:

(a) Committee on Power Boilers (I)
(b) Committee on Materials (II)
(c) Committee on Construction of Nuclear Facility Components (III)
(d) Committee on Heating Boilers (IV)
(e) Committee on Nondestructive Examination (V)
(f) Committee on Pressure Vessels (VIII)
(g) Committee on Welding, Brazing, and Fusing (IX)
(h) Committee on Fiber-Reinforced Plastic Pressure Vessels (X)
(i) Committee on Nuclear Inservice Inspection (XI)
(j) Committee on Transport Tanks (XII)
(k) Committee on Overpressure Protection (XIII)
(l) Technical Oversight Management Committee (TOMC)

Where reference is made to "the Committee" in this Foreword, each of these committees is included individually and collectively.

The Committee's function is to establish rules of safety relating to pressure integrity. The rules govern the construction** of boilers, pressure vessels, transport tanks, and nuclear components, and the inservice inspection of nuclear components and transport tanks. For nuclear items other than pressure-retaining components, the Committee also establishes rules of safety related to structural integrity. The Committee also interprets these rules when questions arise regarding their intent. The technical consistency of the Sections of the Code and coordination of standards development activities of the Committees is supported and guided by the Technical Oversight Management Committee. The Code does not address other safety issues relating to the construction of boilers, pressure vessels, transport tanks, or nuclear components, or the inservice inspection of nuclear components or transport tanks. Users of the Code should refer to the pertinent codes, standards, laws, regulations, or other relevant documents for safety issues other than those relating to pressure integrity and, for nuclear items other than pressure-retaining components, structural integrity. Except for Sections XI and XII, and with a few other exceptions, the rules do not, of practical necessity, reflect the likelihood and consequences of deterioration in service related to specific service fluids or external operating environments. In formulating the rules, the Committee considers the needs of users, manufacturers, and inspectors of components addressed by the Code. The objective of the rules is to afford reasonably certain protection of life and property, and to provide a margin for deterioration in service to give a reasonably long, safe period of usefulness. Advancements in design and materials and evidence of experience have been recognized.

The Code contains mandatory requirements, specific prohibitions, and nonmandatory guidance for construction activities and inservice inspection and testing activities. The Code does not address all aspects of these activities and those aspects that are not specifically addressed should not be considered prohibited. The Code is not a handbook and cannot replace education, experience, and the use of engineering judgment. The phrase *engineering judgment* refers to technical judgments made by knowledgeable engineers experienced in the application of the Code. Engineering judgments must be consistent with Code philosophy, and such judgments must never be used to overrule mandatory requirements or specific prohibitions of the Code.

The Committee recognizes that tools and techniques used for design and analysis change as technology progresses and expects engineers to use good judgment in the application of these tools. The designer is responsible for complying with Code rules and demonstrating compliance with Code equations when such equations are mandatory. The Code neither requires nor prohibits the use of computers for the design or analysis of components constructed to the requirements of the Code. However, designers and engineers using computer programs for design or analysis are cautioned that they are

* The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. Therefore, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Code.

** *Construction*, as used in this Foreword, is an all-inclusive term comprising materials, design, fabrication, examination, inspection, testing, certification, and overpressure protection.

responsible for all technical assumptions inherent in the programs they use and the application of these programs to their design.

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

The Committee meets regularly to consider revisions of the rules, new rules as dictated by technological development, Code cases, and requests for interpretations. Only the Committee has the authority to provide official interpretations of the Code. Requests for revisions, new rules, Code cases, or interpretations shall be addressed to the staff secretary in writing and shall give full particulars in order to receive consideration and action (see the Correspondence With the Committee page). Proposed revisions to the Code resulting from inquiries will be presented to the Committee for appropriate action. The action of the Committee becomes effective only after confirmation by ballot of the Committee and approval by ASME. Proposed revisions to the Code approved by the Committee are submitted to the American National Standards Institute (ANSI) and published at http://go.asme.org/BPVCPublicReview to invite comments from all interested persons. After public review and final approval by ASME, revisions are published at regular intervals in Editions of the Code.

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

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

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

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

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

CORRESPONDENCE WITH THE COMMITTEE

General

ASME codes and standards are developed and maintained by committees with the intent to represent the consensus of concerned interests. Users of ASME codes and standards may correspond with the committees to propose revisions or cases, report errata, or request interpretations. Correspondence for this Section of the ASME Boiler and Pressure Vessel Code (BPVC) should be sent to the staff secretary noted on the Section's committee web page, accessible at https://go.asme.org/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

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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	...

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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	...	...	...

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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	...	...	...

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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	...	...	...

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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	...

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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)

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

CHARTS FOR VESSELS UNDER EXTERNAL PRESSURE

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Case 1325-18
Nickel-Iron-Chromium Alloys 800 and 800H (UNS N08800 and N08810) and Nickel-Iron-Chromium-Molybdenum-Copper Low-Carbon Alloy (UNS N08028)

Section I

Approval Date: June 23, 2005
Code Cases will remain available for use until annulled by the applicable Standards Committee.

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

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

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

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

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

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

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

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

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

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

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

Table 1
Product Specifications

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

Case 1750-32
Materials for Bodies, Bonnets, Yokes, Housings, and Holders of Pressure Relief Devices

(25)

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

Approval Date: February 3, 2025

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

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

SA-351 Grade CK3MCuN
SA-352 Grade LCC
SA-675 Grades 50, 55, 60, 65, and 70
SA-995 Grade CD4MCuN
ASTM A108 Grades 1016, 1018, 1020, 1117, 1118, 1137, 1141, 1215, and 12L14
ASTM A126
ASTM A314 Type 303
ASTM A494/A494M Grades CY-40, CZ-100, and M35-1
ASTM A576 Grades 1040, 1042, 1045, and 1117
ASTM A582 Types 303 and 416
ASTM A744 Grade CK3MCuN
ASTM B16
ASTM B21 Alloys 464, 482, and 485
ASTM B85 Alloy SC84B
ASTM B176 Alloy C85800
ASTM B211 Alloy 2024 Temper 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. $< t \leq$ 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.

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Case 1849-1
Gray Cast Iron Castings

Section I

Approval Date: August 4, 2004

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

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

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

(a) Service Restrictions

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

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

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

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

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

(6) Mating surfaces shall be machined.

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

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

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

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

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

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

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Case 1855-2
Section VIII, Division 1, Unfired Steam Boiler in Section I System

Section I

Approval Date: December 18, 2018

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

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

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

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

(b) Materials

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

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

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

(d) Stamping and Data Reports

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

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

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

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

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Case 1876-6
Design of Safety Valve Connections

Section I

Approval Date: March 4, 2024

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

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

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

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

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

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

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

Temperature, °F	Carbon Steel, ksi [Note (1)] and [Note (2)]	$1^1/_4$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.

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Case 1924-2
Nickel-Molybdenum-Chromium Alloy (UNS N10276)

Section I

Approval Date: December 30, 2006

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

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

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

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

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

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

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

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

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

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

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

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

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Case 1932-5
SA-736/SA-736M Plates and ASTM A859/A859M-95 Forgings

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

Approval Date: August 4, 2006

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

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

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

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

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

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

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

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

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

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

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

(d) Preheat. Preheat is not required when the base metal temperature is 50°F or warmer, for nominal thicknesses up to $1\frac{1}{2}$ 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	
$t \le 3/4$ in.	30.0
Class 2	
$t \le 2$ in.	24.0
2 in. < $t \le 4$ in.	21.7
Class 3	
$t \le 2$ in.	28.3
2 in. < $t \le 4$ in.	25.0
A859	
Class 1	
$t \le 4$ in.	21.7
Class 2	
$t \le 4$ 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							
$t \le 0.75$	80.0	75.3	72.6	69.4	67.6	65.5	64.2
Class 2							
$t \le 1.00$	65.0	61.1	58.6	56.8	54.9	53.2	52.1
$1 < t \le 2$	60.0	56.5	54.1	52.4	50.7	49.1	48.1
$2 < t \le 4$	55.0	51.8	49.6	48.1	46.5	45.0	44.1
Class 3							
$t \le 2$	75.0	70.6	67.6	65.6	63.4	61.4	60.2
$2 < t \le 4$	65.0	61.1	58.6	56.8	54.9	53.2	52.1
A859							
Class 1							
$t \le 4$ in.	55.0	51.8	49.6	48.1	46.5	45.0	44.1
Class 2							
$t \le 4$ in.	65.0	61.1	58.6	56.8	54.9	53.2	52.1

Case 1934
Alternative Rules for Heat Treatment of Boiler External Piping

Section I

Approval Date: May 25, 1983

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

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

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

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

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Case 1935-4
Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625)

Section I

Approval Date: September 23, 2007

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

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

Reply: It is the opinion of the Committee that solution annealed (Grade 2) nickel-chromium-molybdenum-columbium alloy (UNS N06625) as described in the Inquiry may be 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).

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Case 1936-3
Nickel-Iron-Chromium-Molybdenum-Copper Alloy (UNS N08825) for Water Wetted Service

Section I

Approval Date: February 20, 2002
Code Cases will remain available for use until annulled by the applicable Standards Committee.

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

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

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

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

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

(2) The maximum outside diameter shall be $3^1\!/_2$ 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.

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Case 1949-4
Forgings of Nickel-Iron-Chromium Alloys N08800 and N08810

Section I

Approval Date: February 20, 2004
Code Cases will remain available for use until annulled by the applicable Standards Committee.

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

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

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

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

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

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

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

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

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Case 1968-1
Use of Acoustic Emission Examination in Lieu of Radiography

Section VIII, Division 1

Approval Date: December 2, 1990

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

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

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

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

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

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Case 1993-7
Precipitation-Hardening Nickel Alloy (UNS N07718) Used as Bolting Material

Section I

Approval Date: October 26, 2016

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

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

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

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

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

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

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

Table 1
Maximum Allowable Stresses, ksi

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

Table 1M
Maximum Allowable Stresses, MPa

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

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

Case 2016-1
Alternative Requirements for Seal Welding of Threaded Connections, UF-32(b)

Section VIII, Division 1

Approval Date: August 12, 1996

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

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

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

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

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

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

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

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

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Case 2038-5
25Cr-22Ni-2Mo-N, UNS S31050, Austenitic Stainless Steel Forgings

Section VIII, Division 1; Section VIII, Division 2

Approval Date: February 7, 2000
Code Cases will remain available for use until annulled by the applicable Standards Committee.

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

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

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

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

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

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

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

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

Table 1
Chemical Requirements (Heat Analysis)

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

Table 2
Mechanical Property Requirements

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

Table 3
Maximum Allowable Stress Values, Division 1

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

NOTES:
(1) See Note G5 of Table 1A in Section II, Part D.
(2) The revised criterion of 3.5 on tensile strength was used in establishing these values.

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

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

Case 2055-2
Pneumatic Testing of Pressure Vessels, UG-20

Section VIII, Division 1

Approval Date: May 4, 1999

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

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

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

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

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

(c) The following thickness limitations shall apply:

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

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

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

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

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Case 2063-6
Ni-22Cr-14W-2Mo-La Alloy (UNS N06230)

Section I

Approval Date: October 2, 2008

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

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

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

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

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

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

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

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

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

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

Table 1
Product Specifications

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

Table 2
Maximum Allowable Stress Values

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

NOTES:
(1) These values are based on the use of a tensile strength criterion of 3.5.
(2) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 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.

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Case 2120-1
Nickel-Iron-Chromium-Molybdenum-Copper Low Carbon Alloy (UNS N08926) for Code Construction

Section VIII, Division 1

Approval Date: October 29, 1999

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

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

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

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

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

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

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

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

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

Table 1
Chemical Composition

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

Table 2
Mechanical Property Requirements (All Product Forms)

Tensile strength, min., ksi	94.0
Yield strength, min., ksi	43.0
Elongation in 2 in., or 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

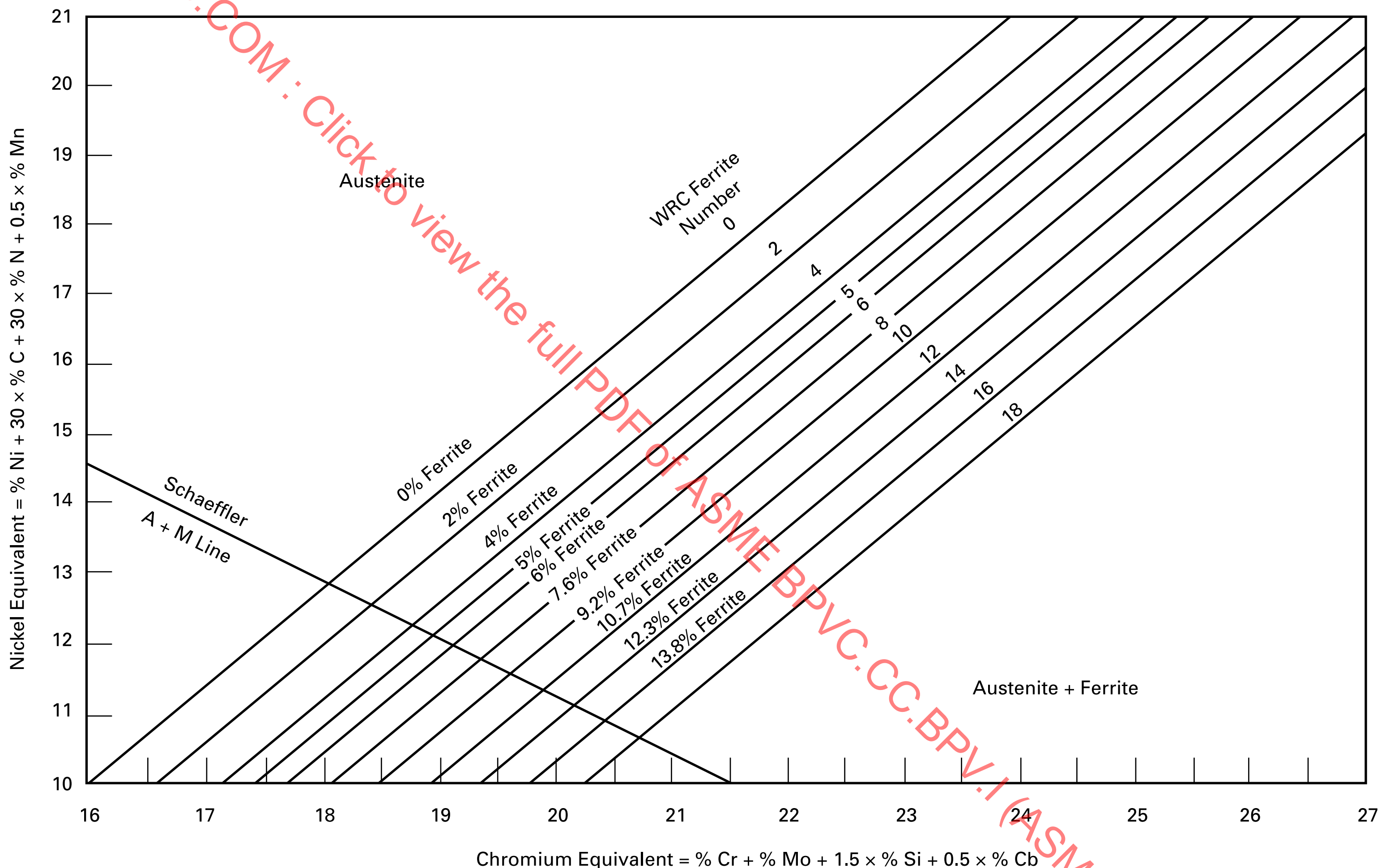
Element	Weight, %
Carbon, max.	0.030
Manganese	[Note (1)]
Phosphorus, max.	0.025
Sulfur, max.	0.015
Silicon	[Note (1)]
Nickel	[Note (1)]
Chromium	[Note (1)]
Nitrogen	0.13–0.16
Other Elements	[Note (1)]

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%

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Case 2142-6
F-Number Grouping for Ni-Cr-Fe Filler Metals

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

Approval Date: August 1, 2018

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

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

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

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

Table 1
Chemical Requirements

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

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

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Case 2143-2
F-Number Grouping for Ni-Cr-Fe, Classification UNS W86152 and UNS W86056 Welding Electrodes

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

Approval Date: April 1, 2014
Code Cases will remain available for use until annulled by the applicable Standards Committee.

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

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

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

Table 1
Chemical Requirements

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

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

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

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Case 2146
24Cr-17Ni-6Mn-4.5Mo-N, UNS S34565, Austenitic Stainless Steel Forgings, Bar, Fittings, Welded and Seamless Pipe and Tube, Plate, Sheet, and Strip

Section VIII, Division 1

Approval Date: November 25, 1992

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

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

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

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

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

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

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

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

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

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

Table 1
Chemical Requirements

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

Table 2
Mechanical Properties Requirements

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

Table 3
Maximum Allowable Stress Values, ksi

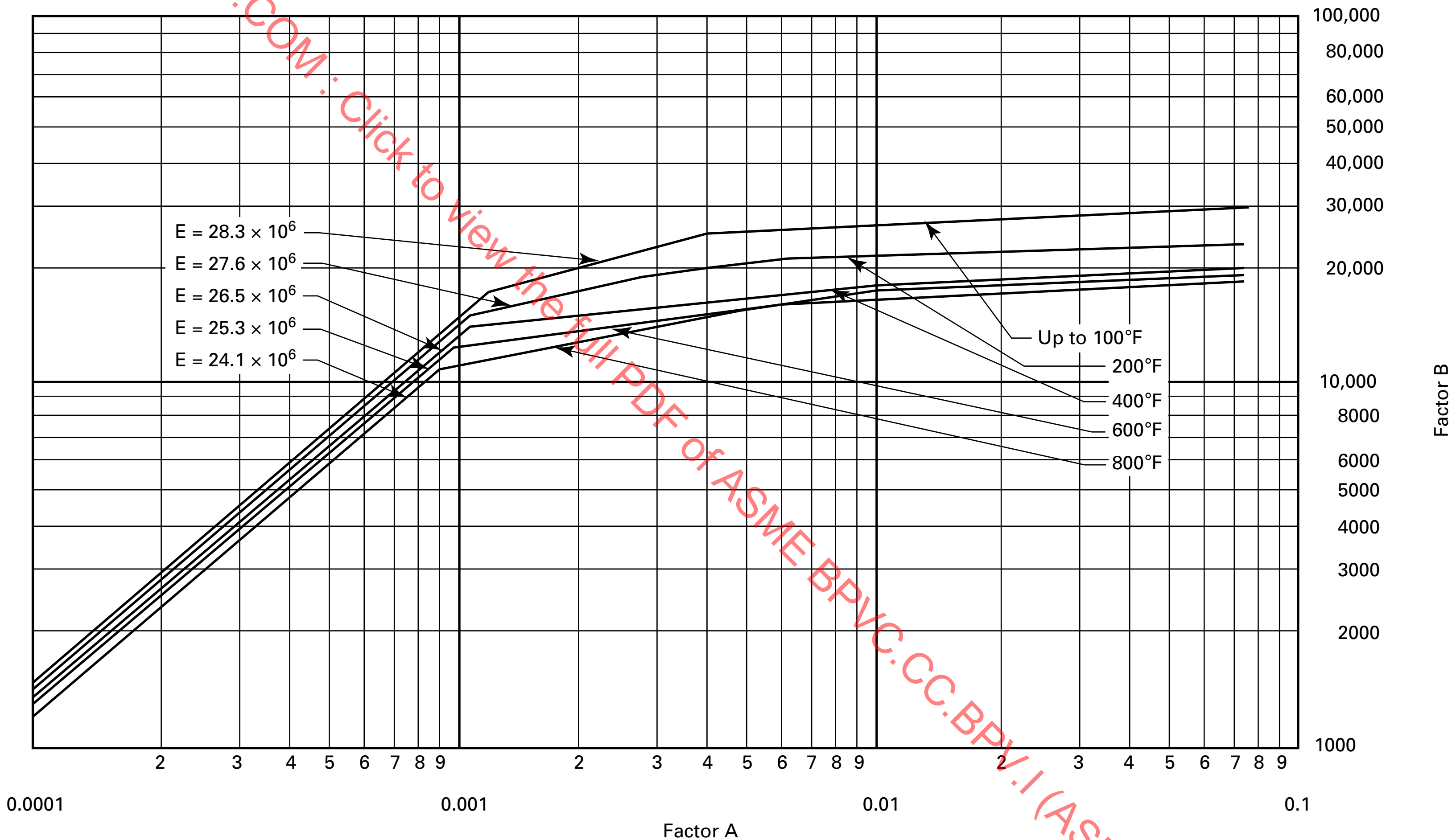
For Metal Temperature Not Exceeding, °F	Forgings, Bar, Plate, Sheet, Strip, Seamless Pipe and Tube, Fittings	Welded Pipe and Tube, Welded Fittings [Note (1)]
100	28.8	24.5
200	28.4	24.1
300	26.9	22.9
400	25.9	22.0
500	25.3	21.5
600	25.0	21.3
650	24.8	21.1
700	24.6	20.9
750	24.3	20.7

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

Table 4
Tabular Values for Figure 1

Up to 100°F, E = 28.3 × 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



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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.

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

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

where

σ_θ = membrane hoop stress plus average discontinuity hoop stress, psi

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

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

P = internal pressure, psi

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

t = cylinder thickness, in.

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

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

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

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

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

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

Figure 1
X* and *Y* For Cone Thickness = *t

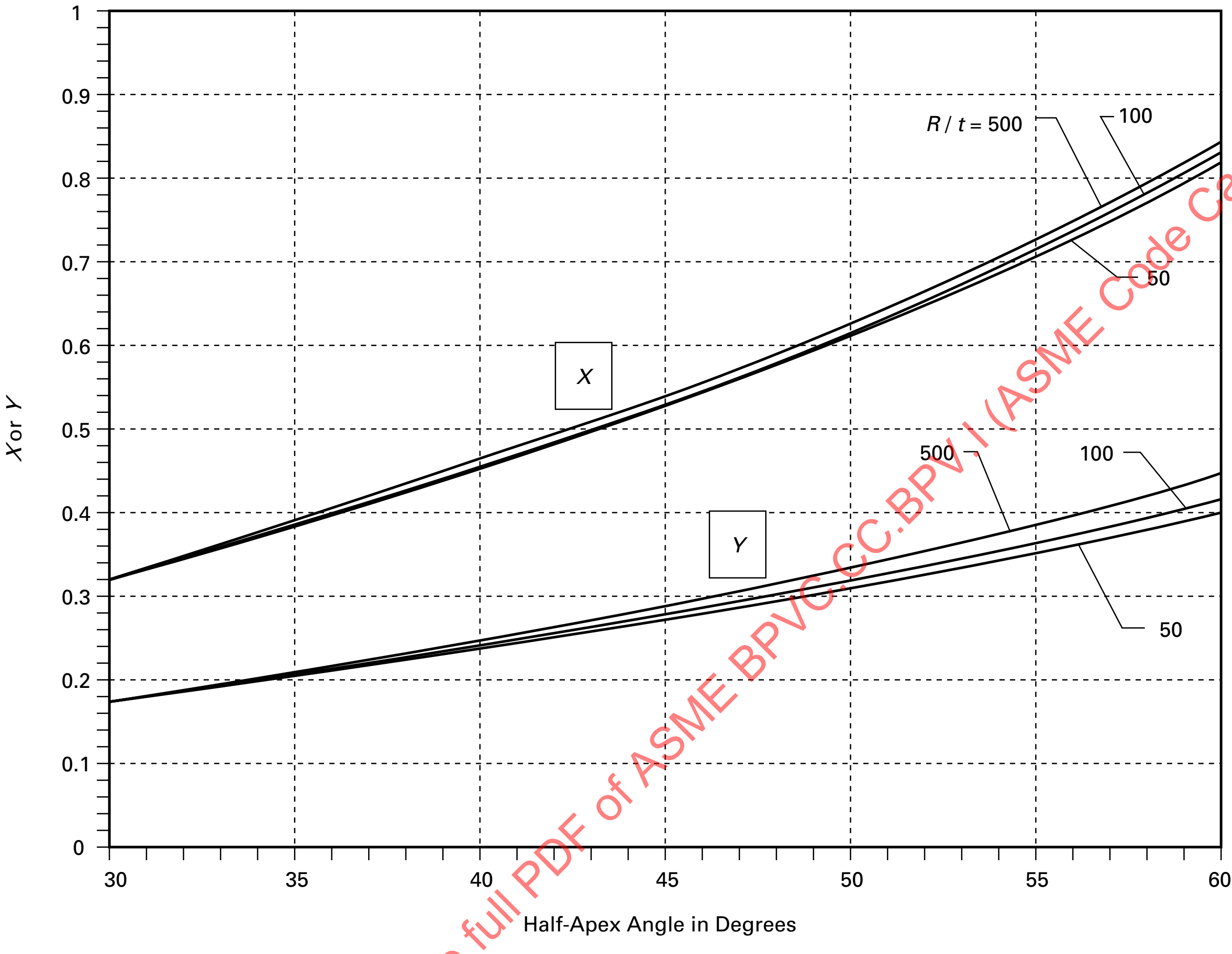


Figure 2
***X* and *Y* For Cone Thickness = *t*/cos α**

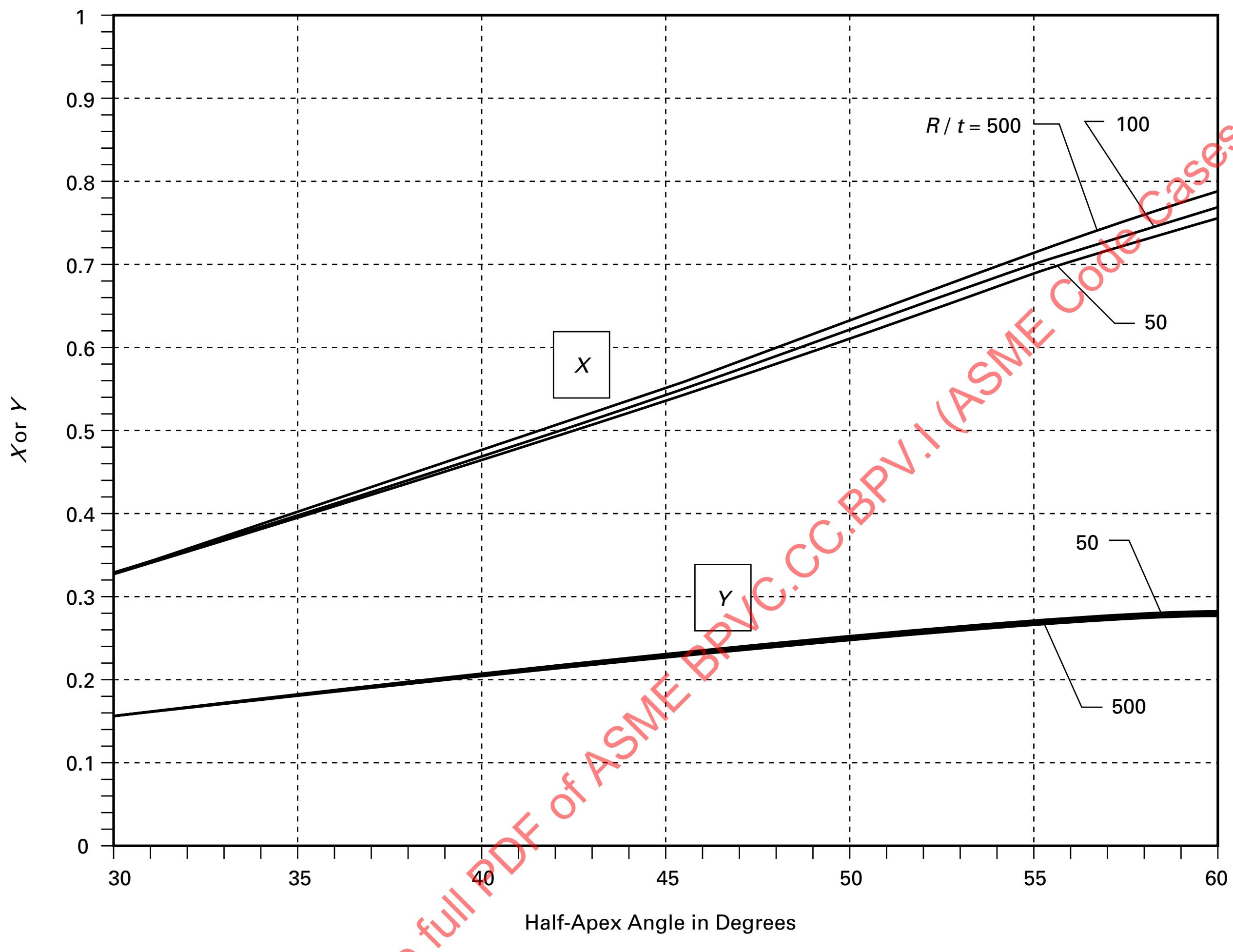


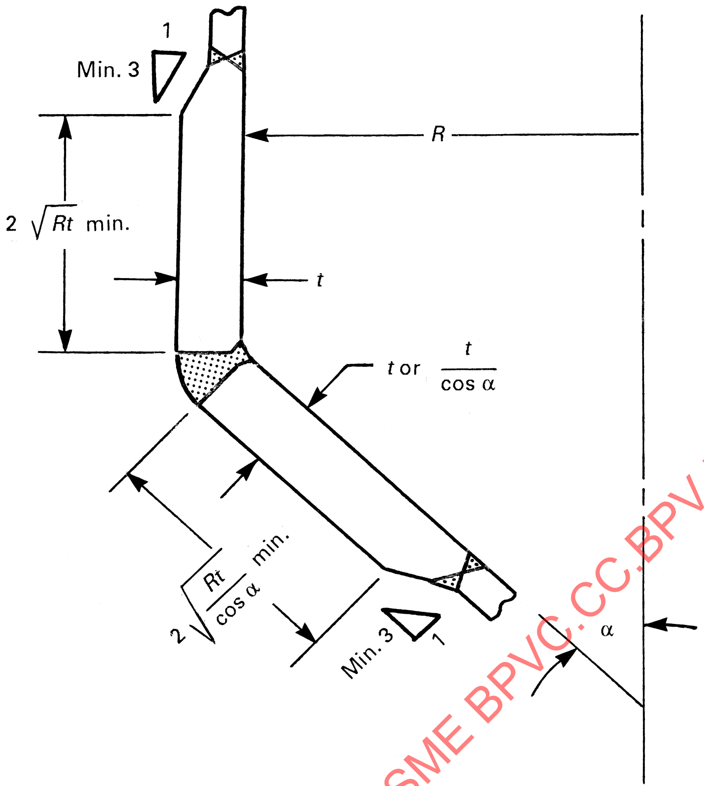
Table 1
Tabular Values for Figure 1

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-$^1/_4$V-Ti-B, which is similar to 3Cr-1Mo-$^1/_4$V-Cb-Ca, except that the creep strength of 3Cr-1Mo-$^1/_4$V-Cb-Ca alloy is slightly higher than that of 3Cr-1Mo-$^1/_4$V-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-$^1/_4$V-Ti-B, which is similar to 3Cr-1Mo-$^1/_4$V-Cb-Ca, except that the creep strength of 3Cr-1Mo-$^1/_4$V-Cb-Ca alloy is slightly higher than that of 3Cr-1Mo-$^1/_4$V-Ti-B.

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

Case 2172
Use of B43 Seamless Red Brass Pipe (UNS C23000) With Drawn General Purpose Temper (H58) for Threaded Piping for Construction of PMB and PEB Miniature Electric Boilers

Section I

Approval Date: August 8, 1994

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

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

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

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

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

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

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

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

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

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Case 2179-12
9Cr-2W, UNS K92460 Material

Section I; Section VIII, Division 1

Approval Date: May 12, 2024

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 1
Material Specifications and Grades

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

Table 2
Maximum Allowable Stress Values

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

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

Table 2M
Maximum Allowable Stress Values

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

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

Table 3
Tensile Strength Values

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

Table 4
Yield Strength Values

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

Table 3M
Tensile Strength Values

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

Table 4M
Yield Strength Values

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

Case 2180-9
Seamless 11Cr-2W Material

(25)

Section I

Approval Date: February 3, 2025

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

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

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

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

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

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

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

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

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

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Case 2195-1
24.5Cr-22Ni-7.5Mo-3Mn-N Austenitic Stainless Steel (UNS S32654)

Section VIII, Division 1

Approval Date: February 7, 2000

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

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

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

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

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

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

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

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

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

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

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

Table 1
Chemical Requirements

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

Table 2
Mechanical Test Requirements (Room Temperature)

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

Table 3
Maximum Allowable Stress Values

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

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

Case 2196-5
Austenitic Stainless Steel Seamless Tubes and Pipe, Seamless Wrought Fittings, Plate, Sheet, and Forgings, 18Cr-11Ni-Cb-N, UNS S34751, 347LN

Section VIII, Division 1

Approval Date: April 2, 2020
Code Cases will remain available for use until annulled by the applicable Standards Committee.

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

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

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

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

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

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

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Case 2199-10
2.25Cr-1.6W-V-Cb Material

Section I

Approval Date: May 12, 2024

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

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

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

(a) The material shall be austenitized within the temperature range of 1,900°F to 1,975°F (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.

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Case 2203-2
Omission of Lifting Device Requirements for Pressure Relief Valves on Air, Water Over 140°F (60°C), or Steam Service

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

Approval Date: December 7, 2022

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

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

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

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

(b) The omission is specified by the user.

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

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Case 2205
Alternate Rules for Heat Treatment of Repair Welds to Castings

Section VIII, Division 1

Approval Date: June 5, 1995

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

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

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

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

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Case 2217-5
Precipitation-Hardening Ni-Cr-Mo Alloy (UNS N07725)

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

Approval Date: June 17, 2003
Code Cases will remain available for use until annulled by the applicable Standards Committee.

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

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

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

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

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

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

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

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

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

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

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

Table 1
Chemical Requirements

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

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

Table 2
Mechanical Property Requirements (Room Temperature)

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

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Case 2224-2
Use of 304L Stainless Steel at Elevated Temperatures

Section VIII, Division 1

Approval Date: September 18, 2006
Code Cases will remain available for use until annulled by the applicable Standards Committee.

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

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

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

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

Table 1
Maximum Allowable Stress Values

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

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

NOTES:
(1) Due to the relatively low yield strength of these materials, these high stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed $66\frac{2}{3}\%$, 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 values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.
(2) Stress values for welded pipe and tube shall be the listed values multiplied by a factor of 0.85.
(3) The revised criterion of 3.5 on tensile strength was used in establishing these values.

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Case 2226-2
Ni-Cr-Mo Alloy UNS N06022 for Code Construction for Temperatures up to 1250°F

Section I

Approval Date: May 21, 2003
Code Cases will remain available for use until annulled by the applicable Standards Committee.

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

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

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

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

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

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

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

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

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

Table 1
Product Specifications

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

Table 2
Maximum Allowable Stress Values

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

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

NOTES:

(1) Alloy N06022 in the solution annealed condition is subject to severe loss of impact properties at room temperature after exposure in the range of 1000°F to 1250°F.

(2) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 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.

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

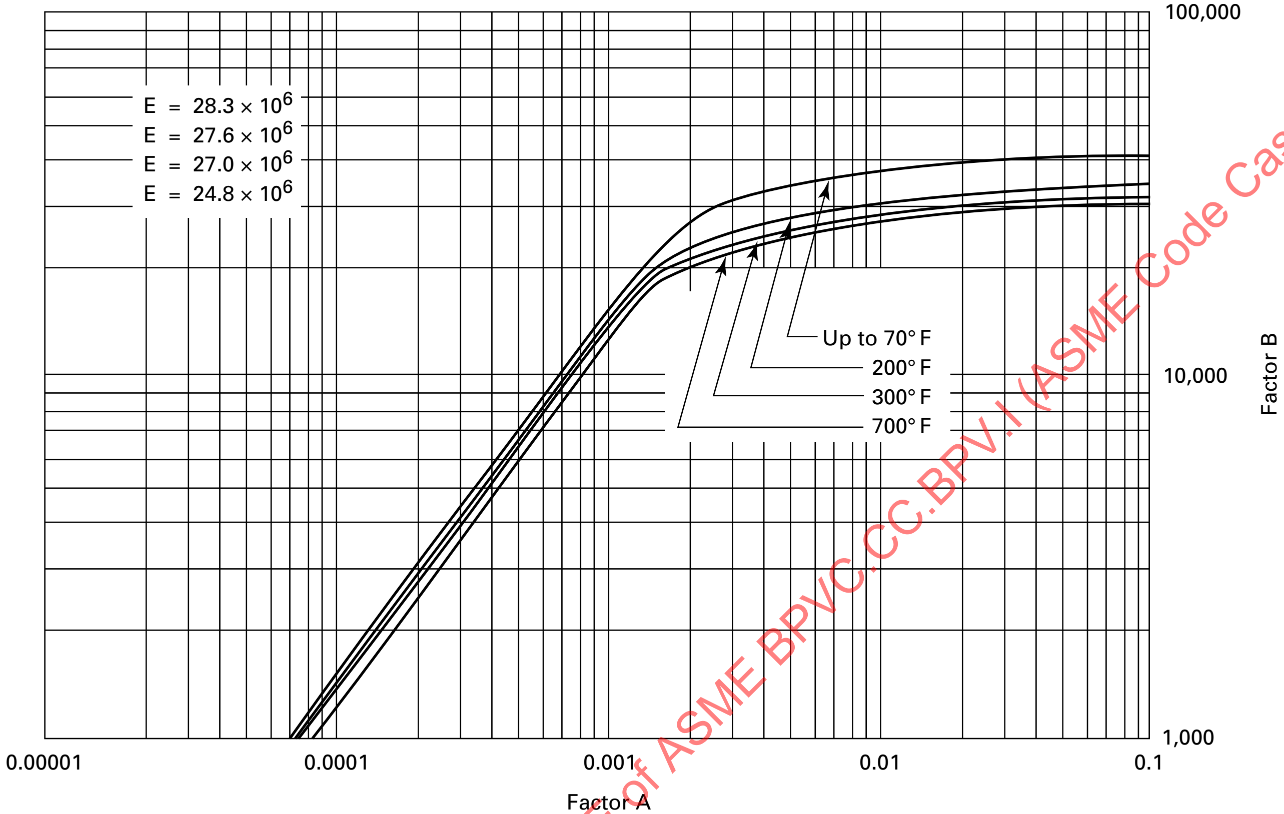

Table 4
Chart for Determining Shell Thickness of Cylindrical and Spherical Shells Under External Pressure When Constructed of High Alloy UNS S32760 And UNS J93380

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

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Case 2247
Alternative Pressure Test Procedure to UG-99 and UG-100 for the Construction of Multistream Aluminum Vacuum Brazed Plate-Fin Heat Exchangers

Section VIII, Division 1

Approval Date: July 9, 1998
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: In Section VIII, Division 1, may an alternative pressure test procedure be implemented in the construction of multistream aluminum vacuum brazed plate-fin heat exchangers that differs from the testing requirements of UG-99 and UG-100?

Reply: It is the opinion of the Committee that multistream aluminum vacuum brazed plate-fin heat exchangers constructed to the rules of Section VIII, Division 1, may be pressure tested in accordance with the following procedure in lieu of the requirements of UG-99 and UG-100.

(a) As a minimum, the vessel shall receive two pressure tests:

(1) first, a hydrostatic test in accordance with UG-99;

(2) all subsequent tests are pneumatic pressure tests.

(b) The hydrostatic test shall be conducted in accordance with UG-99, including witness by the AI. All requirements of UG-99 shall be satisfied. To facilitate filling and draining of each vessel chamber (stream), vent holes shall be drilled into the header ends, as required, to purge each chamber of trapped air.

(c) Following the hydrostatic test, the vent holes shall be welded shut using procedures and welders qualified in accordance with Section IX.

(d) The exchangers are subsequently tested by a procedure employing both pneumatic and solution film leak tests to disclose leaks in the sheet to bar brazed joints that cannot be detected by the hydrotest. The test procedure shall be as follows:

(1) Prior to application of the pneumatic and solution film leak tests the vessel shall be dried.

(2) The pneumatic fill rate is computer controlled such that the pressure is gradually increased from zero to full pressure with a fill rate decrease starting at 80% of the final pneumatic pressure. There are no intermediate stop points during the filling process. The pneumatic test pressure shall satisfy UG-100(b).

(3) The pneumatic test (pressurization cycle) shall be automatically recorded on a strip chart.

(4) The AI is afforded the option but is not required to witness either the pneumatic test or the solution film leak test.

(5) Any leaks identified in brazed joints shall be repaired using a weld repair procedure pre-accepted by the AI. The existence of any such leaks requiring repair requires a repeat of the test procedure. The AI shall be advised of the repair and afforded the option to witness the retest at his discretion.

(6) The final pneumatic test pressure charts and film leak test records shall be certified by the Manufacturer and made available to the AI for his/her review.

(e) Under Item II of the Form U-1 (Manufacturer's Data Report) for Hydrostatic or Pneumatic Test Pressure, reference shall be made to Form U-4 where the hydrostatic test pressure and all pneumatic test pressures shall be listed for each independent pressure chamber of the heat exchanger.

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

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Case 2249
Use of Furnace Brazing for Lethal Service

Section VIII, Division 1

Approval Date: August 11, 1997
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May vessels intended for lethal service made of nickel (UNS N02200 and/or N02201) be fabricated by vacuum furnace brazing using nickel alloy brazing filler metal?

Reply: Vessels intended for lethal service may be fabricated by brazing under the following conditions:

(a) The design temperature shall not exceed 200°F and the design pressure shall not exceed 2000 psi. The diameter of the vessel shall not exceed NPS 8, and the volume of the vessel shall not exceed 5 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

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Case 2276-1
Austenitic Ni-Cr-Mo-Nb Alloy (UNS N06626)

Section VIII, Division 1

Approval Date: February 17, 2000

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

Inquiry: May austenitic Ni-Cr-Mo-Nb alloy (UNS N06626), up to and including 0.100 in. in thickness, wrought sheet and strip, welded pipes, welded tubes, and welded fittings with the chemical analysis shown in Table 1, the minimum mechanical properties shown in Table 2, and the grain size requirements shown in Table 3 be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in Section VIII, Division 1 construction up to a design temperature of 800°F, provided the following additional requirements are met.

(a) The rules in Section VIII, Division 1 that shall apply are those given in Part UNF for nickel alloys.

(b) The maximum allowable stress values for the material shall be those given in Table 4. For welded pipes, tubes, and fittings, a joint efficiency factor of 0.85 shall be used.

(c) Material shall conform to all other requirements of SB-443, SB-704, SB-705, and SB-366, as applicable.

(d) Material shall be considered as P-No. 43.

(e) Heat treatment after forming or fabrication is neither required nor prohibited. However, if heat treatment is conducted, the resulting material must still comply with the requirements of Tables 2 and 3.

(f) The applicable external pressure chart shall be Fig. NFN-17 in Section II, Part D.

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

Table 1
Chemical Requirements

Element	Composition Limits, %
Nickel [Note (1)]	Remainder
Chromium	20.0–23.0
Molybdenum	8.0–10.0
Niobium	3.15–4.15
Iron	5.0 max.
Carbon	0.03 max.
Silicon	0.15 max.
Nitrogen	0.02 max.
Manganese	0.50 max.
Sulfur	0.015 max.
Aluminum	0.40 max.
Titanium	0.40 max.
Phosphorus	0.015 max.
Cobalt	1.0 max.

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

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength, min., ksi	120
Yield strength, 0.2%, offset min., ksi	60
Elongation in 2 in. gage or 4D min., %	40

Table 3
ASTM Grain Size No. Requirements

Up to 0.010 in., incl.	8 or finer
0.010 to 0.050 in., incl.	6 or finer
0.050 to 0.100 in., incl.	5 or finer

Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, Max., ksi [Note (1)]
100	34.3
200	34.3
300	33.9, 34.3 [Note (2)]
400	32.6, 34.3 [Note (2)]
500	31.7, 34.3 [Note (2)]
600	31.1, 34.3 [Note (2)]
650	30.8, 34.3 [Note (2)]
700	30.5, 34.3 [Note (2)]
750	30.3, 34.3 [Note (2)]
800	30.1, 34.1 [Note (2)]

NOTES:
(1) The revised criterion of 3.5 on tensile strength was used in establishing these values.
(2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}$%, but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction.

Case 2286-6
Alternative Rules for Determining Allowable External Pressure and Compressive Stresses for Cylinders, Cones, Spheres, and Formed Heads

Section VIII, Division 1

Approval Date: October 30, 2015
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May alternative rules for determining allowable external pressure and compressive stresses for cylinders, cones, spheres, and formed heads be used for the design of these components in lieu of the rules of Section VIII, Division 1, UG-23, UG-28, UG-29, UG-33, and Appendix 1-8?

Reply:

(a) It is the opinion of the Committee that cylinders, cones, spheres, and formed heads for pressure vessels otherwise designed and constructed in accordance with the rules of Section VIII, Division 1, may be designed using the following rules for calculation of allowable external pressure and compressive stresses in lieu of the rules stated in the Inquiry above.

(b) When used, this Case shall be made applicable to the entire vessel.

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

1 SCOPE, DESIGN, METHOD, AND NOMENCLATURE

1.1 SCOPE

This Case provides alternative rules to those given in Section VIII, Division 1, UG-23(b), UG-28, UG-29, UG-33 and Appendix 1-8 for determining allowable compressive stresses for unstiffened and ring stiffened circular cylinders and cones, and for unstiffened spherical, ellipsoidal, and torispherical heads. The allowable stress equations are based upon theoretical buckling equations that have been reduced by knockdown factors and by plasticity reduction factors that were determined from tests on fabricated shells. (Nomenclature is provided in 1.4.)

This Case expands the coverage of load conditions and shell geometries, and includes equations for combinations of loads not considered in the Code paragraphs referenced above. These alternative rules are applicable to D_o/t ratios not exceeding 2,000, compared to the $D_o/t = 1,000$ limit is Fig. G in Subpart 3 of Section II, Part D. The slenderness limit for these rules in $KL_u/r \leq 200$. Use of these alternative rules assumes the shell section to be axisymmetric with uniform thickness for unstiffened cylinders and formed heads. Stiffened cylinders and cones are also assumed to be of uniform thickness between stiffeners. Where nozzles with reinforcing plates or locally thickened shell sections exist, use the thinnest uniform thickness in the applicable unstiffened or stiffened shell section for calculation of allowable compressive stress.

The maximum temperature permitted for use of this Case is shown in Table 1.

Alternative equations for determination of allowable compressive stress due to loads specified in UG-22 are provided. A listing of the allowable stress cases, combinations of cases, requirements for tolerances, and reinforcement of openings by Case paragraph number is given in Table 2, with indication of present coverage in Division 1.

1.2 BUCKLING DESIGN METHOD

The buckling strength formulations presented in this Case are based on classical linear theory with simple support boundary conditions and Poisson's ratio of 0.3. The differences between elastic stresses obtained for buckling tests on fabricated shells and the theoretical

Table 1

Table in Which Material is Listed, Division 1	Max. Temperature, °F
UCS-23.1	800
UNF-23.1	300
UNF-23.2	150
UNF-23.3	900
UNF-23.4	600
UNF-23.5	600
UHA-23	800
UHT-23	700

Table 2

Para. No.	Subject	Covered in Div. 1
3	Allowable Compressive Stresses for cylindrical shells	Yes, in part
3.1	External Pressure	Yes
3.2	Uniform axial compression	Yes
3.2.1	Local buckling	Yes
3.2.2	Column buckling	No
3.3	Axial compression due to bending	No
3.4	Shear	No
4	Allowable Compressive Stresses for Cones	Yes, in part
4.1	External pressure	Yes
4.1.1	Allowable Circumferential Compression Stresses	Yes
4.1.2	Intermediate Stiffener Rings	No
4.1.3	Cone-Cylinder Junction Rings	Yes
4.2	Uniform Axial Compression and Bending	Yes, in part
4.2.1	Allowable Longitudinal and Bending Stresses	Yes
4.2.2	Unstiffened Cone-Cylinder Junctions	Yes
4.2.3	Cone-Cylinder Junction Rings	Yes
4.3	Shear	No
4.4	Local Stiffener Geometry Requirements	No
5	Allowable Stress Equations for Unstiffened and Ring Stiffened Cylinders and Cones Under Combined Loads	No
5.1	Combination of Uniform Axial Compression & Hoop Compression	No
5.2	Combination of Axial Compression Due to Bending Moment, M, and Hoop Compression	No
5.3	Combination of Hoop Compression and Shear	No
5.4	Combination of Uniform Axial Compression, Axial Compression Due to Bending Moment, M, and Shear in the Presence of Hoop Compression	No
5.5	Combination of Uniform Axial Compression, Axial Compression Due to Bending Moment, M, and Shear in the Absence of Hoop Compression	No
6	Sizing of Rings (General Instability)	Yes, in part
6.1	External pressure	Yes, but only (b)
6.2	Uniform Axial Compression and Axial Compression — Bending	No
6.3	Shear	No
6.4	Local Stiffener Geometry Requirements	No
7	Tolerances for Cylindrical & Conical Shells	Yes, in part
7.1	Shells Subjected to Internal Pressure	Yes, in part
7.2	Shells Subjected to Uniform Axial Compression and Axial Compression Due to Bending Moment	No
7.3	If Tolerances are Exceeded, Allowable Buckling Stress Adjustment	No
7.4	Measurements for Deviation	Yes, in part
7.5	Shells Subjected to Shear	Yes
8	Allowable Compressive Stresses for Spherical Shells and Formed Heads, with Pressure on Convex Side	Yes, in part
8.1.1	Spherical Shells with Equal Biaxial Stresses	Yes
8.1.2	Spherical Shells with Unequal Biaxial Stresses, both Compressive	No
8.1.3	Spherical Shells with Unequal Biaxial, one stress compressive and the other tensile	No
8.1.4	Shear	No
8.2	Toroidal and Ellipsoidal Heads	Yes, in part
8.3	Tolerances for Formed Heads	Yes, in part
9	Reinforcement for Openings	Yes, in part

buckling stresses are accounted for by knockdown factors. These factors are equivalent to the ratio of strain in a fabricated shell at buckling stress and the strain corresponding to the theoretical buckling stress. The design equations apply to shells with initial imperfections within the specified fabrication tolerances of 7 and 8.3.

The design of cylinders and cones for compressive loads is an iterative procedure. The first step in the design process is to assume a shell geometry and thickness and calculate the resulting stresses from dead and live (including pressure) loads. The next step is to calculate the allowable stresses for individual load cases and substitute these values into interaction equations for combined load cases. The shell thickness or geometry can be adjusted to give the desired agreement between applied and allowable stresses.

The next step is to determine the stiffener sizes if rings are used. The stiffener elements must satisfy the requirements of 6.4 to prevent local buckling of the stiffener.

Special consideration shall be given to ends of members (shell sections) or areas of load application where stress distribution may be in the inelastic range and localized stresses may exceed those predicted by linear theory. When the localized stresses extend over a distance equal to one half the length of a buckle node (approximately $1.2\sqrt{D_o t}$), 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

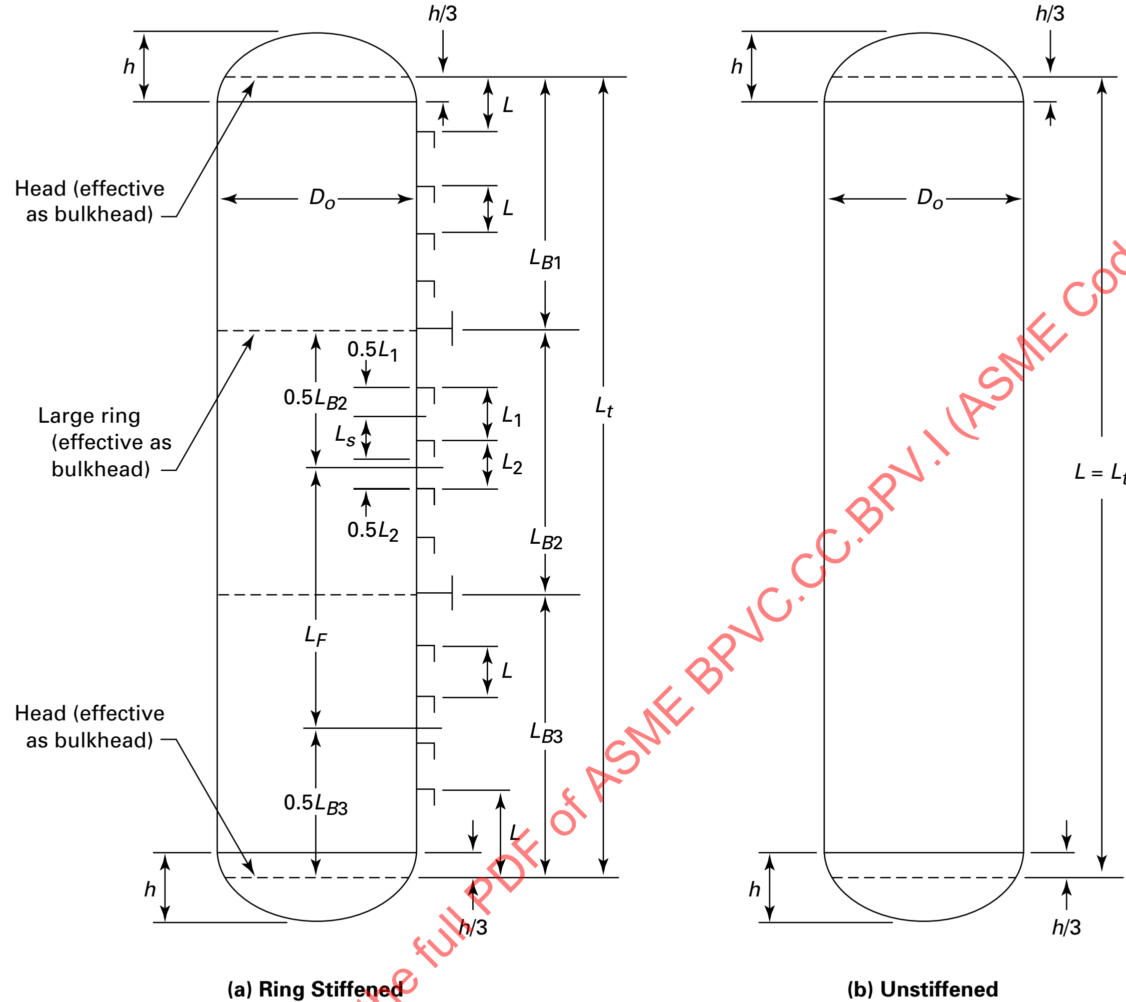
F_{ha} = allowable hoop compressive membrane stress of a cylinder or formed head under external pressure alone, ksi

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 $\lambda_c \le 0.15$, 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 $\lambda_c \le 0.15$, ksi

F_{xe} = elastic axial compressive membrane failure (local buckling) stress of a cylinder in the absence of other loads, ksi

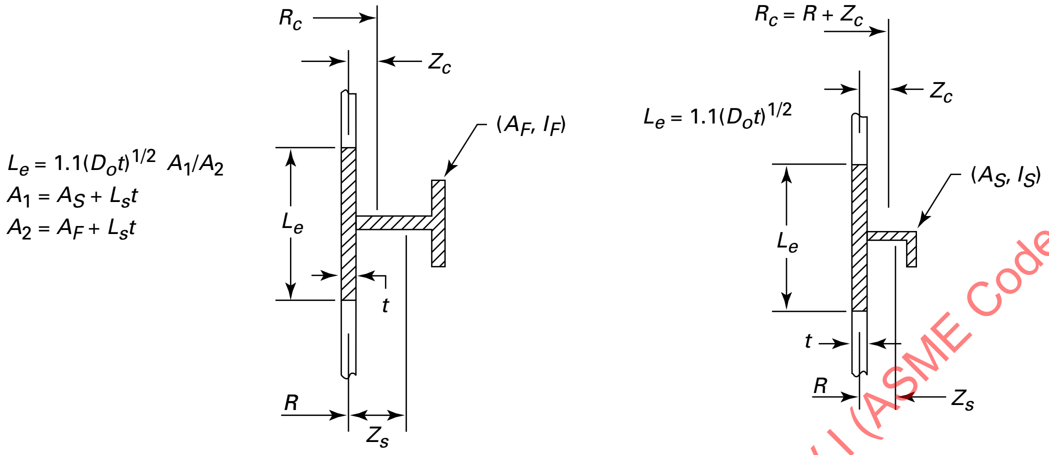
F_{xha} = allowable axial compressive membrane stress of a cylinder in the presence of hoop compression for $\lambda_c \le 0.15$, ksi.

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}

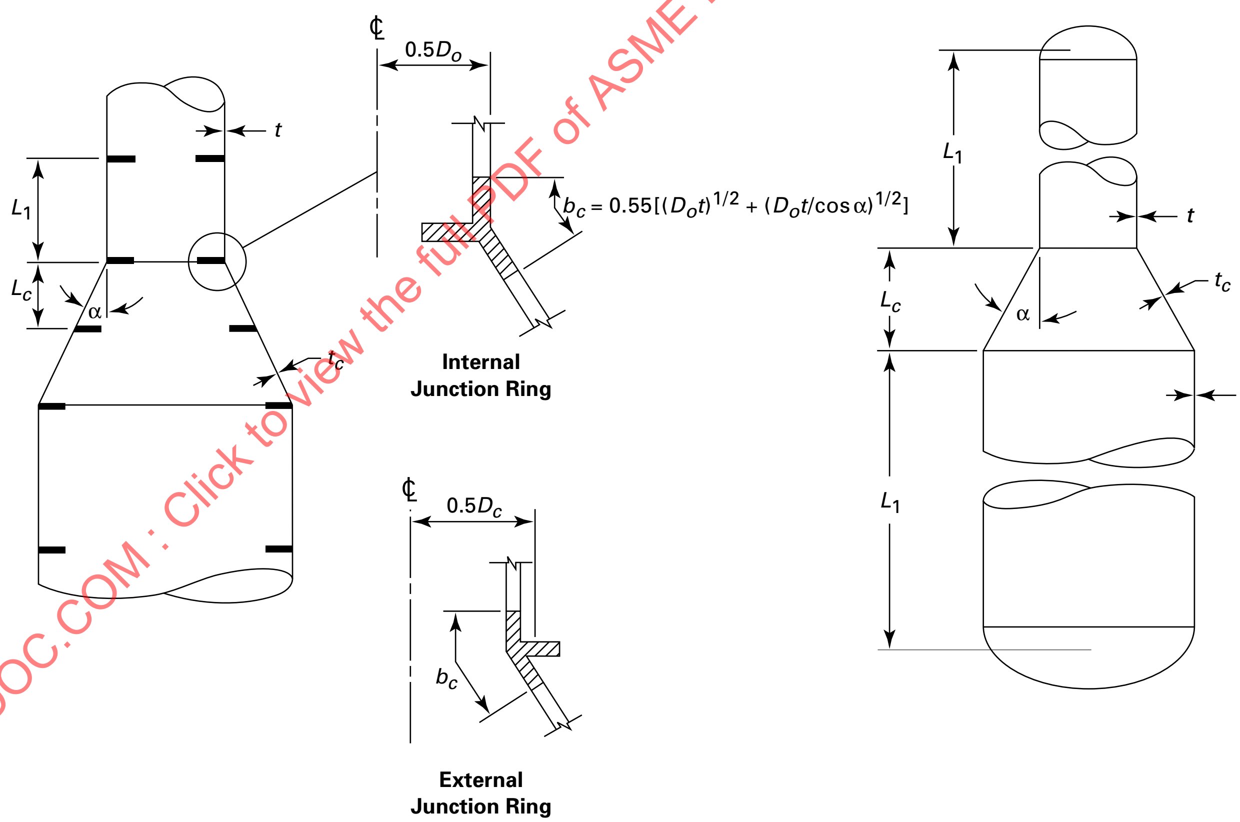
Figure 1.4.2
Sections Through Rings



(a) Large Ring That Acts as a Bulkhead

(b) Small Ring

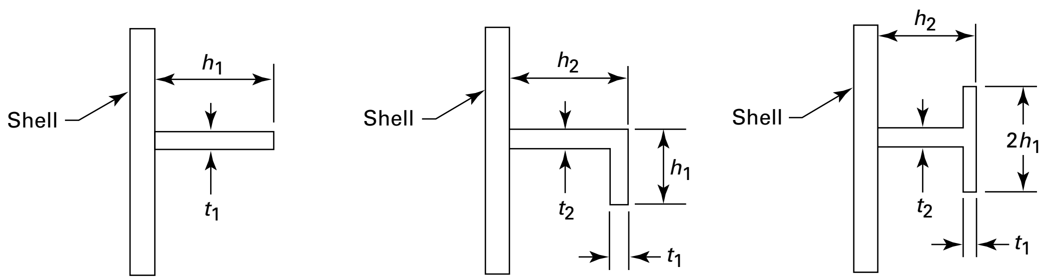
Figure 1.4.3
Geometry of Conical Sections



(a) Stiffened

(b) Unstiffened

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



(a) Bar (b) Angle (c) Tee

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:

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

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

(b) Unstiffened and ring stiffened cylinders and cones under external pressure: $\beta = 0.8$

(c) Spherical, torispherical, and ellipsoidal heads under external pressure: $\beta = 0.124$

2.4 STRESS COMPONENTS FOR STABILITY ANALYSIS AND DESIGN

Stress components that control the buckling of a cylindrical shell consist of longitudinal, circumferential, and in-plane shear membrane stresses.

3 ALLOWABLE COMPRESSIVE STRESSES FOR CYLINDRICAL SHELLS

The maximum allowable stresses for cylindrical shells subjected to loads that produce compressive stresses are given by the following equations. For stress components acting alone, the maximum values shall be used. For combined stress components, the concurrent (coexisting) stress values shall be used.

In no case shall the allowable primary membrane compressive stresses exceed the maximum allowable tensile stress listed in Section II, Part D.

3.1 EXTERNAL PRESSURE

The allowable circumferential compressive stress for a cylinder under external pressure is given by F_{ha} and the allowable external pressure is given by the following equation.

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

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

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

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

where

$$F_{he} = 1.6C_hE\frac{t}{D_o} \tag{3-2}$$

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

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

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

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

3.2 UNIFORM AXIAL COMPRESSION

Allowable longitudinal stress for a cylindrical shell under uniform axial compression is given by F_{xa} for values of $\lambda_c \leq 0.15$ and by F_{ca} for values of $\lambda_c > 0.15$.

$$\lambda_c = \frac{KL_u}{\pi r}\sqrt{\frac{F_{xa}FS}{E}}$$

where KL_u is the effective length. L_u is the unbraced length. Minimum values for K are:

(a) 2.1 for members with one end free and the other end fixed (i.e., "free standing" pressure vessels supported at grade)

(b) 1.0 for members with both ends pinned

(c) 0.8 for members with one end pinned and the other end fixed

(d) 0.65 for members with both ends fixed

In this case, “member” is the unbraced cylindrical shell or cylindrical shell section as defined in the Nomenclature, 1.4.

3.2.1 LOCAL BUCKLING (FOR $\lambda_c \leq 0.15$).

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

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

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

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

or

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

where

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

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

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

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

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

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

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

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 $0.15 < \lambda_c < 1.2$

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

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}.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4 ALLOWABLE COMPRESSIVE STRESSES FOR CONES

Unstiffened conical transitions or cone sections between rings of stiffened cones with an angle $\alpha \leq 60$ deg shall be designed for local buckling as an equivalent cylinder according to the following procedure. See Figure 1.4.3 for cone geometry.

4.1 EXTERNAL PRESSURE

4.1.1 Allowable Circumferential Compression Stresses. Assume an equivalent cylinder with diameter, D_e, equal to $0.5\,(D_L + D_S)/\cos\alpha$, $L_{ce} = L_c/\cos\alpha$. The value D_e is substituted for D_o, L_{ce} for L, and $D_e/2$ for R_o in the equations given in 3.1 to determine F_{ha}. The allowable stress must be satisfied at all cross-sections along the length of the cone.

4.1.2 Intermediate Stiffening Rings. If required, circumferential stiffening rings within cone transitions shall be sized using eq. 6.1(a)(6-1).

4.1.3 Cone-Cylinder Junction Rings. A junction ring is not required for buckling due to external pressure if $f_h < F_{ha}$ where F_{ha} is determined from eqs. 3.1(3-1a) through 3.1(3-1c) with F_{he} computed using C_h equal to $0.55\,(\cos\alpha)\,(t/D_o)$ in eq. 3.1(3-2). D_o is the cylinder diameter at the junction. The hoop stress may be calculated from the following equation.

$$f_h = \frac{PD_o}{2t_c\cos\alpha}$$

If $t_c\cos\alpha$ is less than t, then substitute t for t_c to determine C_h and f_h.

Circumferential stiffening rings required at the cone-cylinder junctions shall be sized such that the moment of inertia of the composite ring section satisfies the following equation:

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

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}.

$$f_x \leq F_{xha}$$

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

where

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

and

$$C_2 = \frac{f_x}{f_h} \tag{5-1b}$$

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

Equation (5-1) should not be used (does not apply) if either f_h is not present (or not being considered), or $f_x = 0$. $F_{xa}\ FS$ is given by the smaller of eqs. 3.2.1(3-3a) through 3.2.1(3-3c) or eq. 3.2.1(3-4), and $F_{ha}\ FS$ is given by eqs. 3.1(3-1a) through 3.1(3-1c). To determine F_{xa} and F_{ha} the values of FS are obtained from 2.2.

$$F_{hxa} = \frac{F_{xha}}{C_2} \tag{5-2}$$

The values of FS are to be determined independently for the axial and hoop directions.

5.1.2 For $0.15 < \lambda_c < 1.2$, the allowable stress in the longitudinal direction is given by F_{aha}, and is determined from column buckling considerations. (The rules do not apply to values of $\lambda_c \geq 1.2$ for shells under combined axial compression and external pressure.)

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

The load on the end of a cylinder due to external pressure does not contribute to column buckling and therefore F_{aha} is compared with f_a rather than f_x. The stress due to the pressure load does, however, lower the effective yield stress and the quantity in parentheses $(1 - f_q/F_y)$ accounts for this reduction. F_{cha} is obtained from eqs. 3.2.2(3-7a) and 3.2.2(3-7b) by substituting F_{xha}, determined from eq. 5.1.1(5-1) for F_{xa}. The resulting equations are:

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

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

5.2 FOR COMBINATION OF AXIAL COMPRESSION DUE TO BENDING MOMENT, *M*, AND HOOP COMPRESSION

The allowable stress in the longitudinal direction is given by F_{bha}, and the allowable stress in the circumferential direction is given by F_{hba}.

$$F_b \leq F_{bha}$$
$$F_{bha} = C_3 C_4 F_{ba} \tag{5-4}$$

where C_3 and C_4 are given by the following equations and F_{ba} is given by eqs. 3.3(3-8a) through 3.3(3-8e).

$$C_4 = \frac{f_b}{f_h}\frac{F_{ha}}{F_{ba}} \tag{5-4a}$$

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

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

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

$$F_{hba} = F_{bha}\frac{f_h}{f_b} \tag{5-6}$$

5.3 FOR COMBINATION OF HOOP COMPRESSION AND SHEAR

The allowable shear stress is given by F_{vha} and the allowable circumferential stress is given by F_{hva}.

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

where

$$C_5 = \frac{f_v}{f_h}$$
$$f_v = V\sin\phi/\pi Rt$$

F_{va} is given by eq. 3.4(3-9) and F_{ha} is given by eq. 3.1(3-1a).

$$F_{hva} = \frac{F_{vha}}{C_5} \quad (5\text{-}8)$$

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

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

5.4.1 For $\lambda_c \leq 0.15$

$$\left(\frac{f_a}{K_sF_{xha}}\right)^{1.7} + \frac{f_b}{K_sF_{bha}} \leq 1.0 \quad (5\text{-}10)$$

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 $0.15 < \lambda_c < 1.2$

$$\frac{f_a}{K_sF_{aha}} + \frac{8}{9}\frac{\Delta f_b}{K_sF_{bha}} \leq 1.0 \quad (5\text{-}11)$$

$$\text{for } \frac{f_a}{K_sF_{aha}} \geq 0.2 \quad (5\text{-}12)$$

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

where

$$\Delta = \frac{C_m}{1 - \frac{f_aFS}{F_e}} \quad (5\text{-}12a)$$

$$F_e = \frac{\pi^2E}{(KL_u/r)^2} \quad (5\text{-}12b)$$

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 $\lambda_c \leq 0.15$

$$\left(\frac{f_a}{K_sF_{xa}}\right)^{1.7} + \frac{f_b}{K_sF_{ba}} \leq 1.0 \quad (5\text{-}13)$$

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 $0.15 < \lambda_c < 1.2$

$$\frac{f_a}{K_sF_{ca}} + \frac{8}{9}\frac{\Delta f_b}{K_sF_{ba}} \leq 1.0 \quad \text{for} \frac{f_a}{K_sF_{ca}} \geq 0.2 \tag{5-14}$$

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

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

$$I_s' \geq \frac{1.5 \quad F_{he} \quad L_sR_c^2t}{E(n^2 - 1)} \tag{6-1}$$

where

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

$n^2 = \dfrac{2D_o^{3/2}}{3L_Bt^{1/2}}$

n = 2 for $n^2 \leq 4$
= 10 for $n^2 > 100$

(b) Large rings that act as bulkheads

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

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

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 $L_e = 1.1\sqrt{D_ot}\,(A_1/A_2)$

A_1 = cross-sectional area of small ring plus shell area equal to L_st, in.^{2}

A_2 = cross-sectional area of large ring plus shell area equal to L_st, in.^{2}

R_c = radius to centroid of combined large ring and effective width of shell, in.

6.2 UNIFORM AXIAL COMPRESSION AND AXIAL COMPRESSION DUE TO BENDING

When ring stiffeners are used to increase the allowable longitudinal compressive stress, the following equations must be satisfied. For a stiffener to be considered, M_x shall be less than 15.

$$A_s \geq \left[\frac{0.334}{M_s^{0.6}} - 0.063\right]L_st \quad \text{and} \quad A_s \geq 0.06L_st \tag{6-3}$$

$$\text{also} \quad I_s' \geq \frac{5.33L_st^3}{M_s^{1.8}} \tag{6-4}$$

6.3 SHEAR

$$I_s' \geq 0.184\,C_vM_s^{0.8}t^3L_s \tag{6-5}$$

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

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

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

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

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).

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

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

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

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

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:

$$L_e = 3.72\sqrt{Rt} \quad (8\text{-}7)$$

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 $d \leq 0.4\sqrt{Rt}$

$$A_r = 0 \quad (9\text{-}1)$$

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

$$A_r = 0.5dt_r \quad (9\text{-}2)$$

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

$$A_r = 1.0dt_r \quad (9\text{-}3)$$

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.

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Miller, C.D., "The Effect of Initial Imperfections on the Buckling of Cylinders Subjected to External Pressure," PVRC Grant 94-28. Welding Research Council Bulletin 443, Report No. 1, July 1999.

"Commentary on the Alternative Rules for Determining Allowable Compressive Stresses for Cylinders, Cones, Spheres, and Formed Heads for Section VIII, Divisions 1 and 2," PVRC Grant 99-07, Welding Research Council Bulletin 462, June 2001.

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Case 2297
F-Number Grouping for 9Cr-1Mo-V FCAW Consumable

Section I; Section II, Part A; Section II, Part B; Section II, Part C; Section II, Part D; Section IV; Section VIII, Division 1; Section VIII, Division 2; Section VIII, Division 3; Section IX; Section X; Section XII; Section III, Division 1; Section III, Division 2; Section III, Division 3; Section III, Division 5; Section XI, Division 1

Approval Date: November 30, 1999
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: What alternative rules may be applied to grouping welding filler metal meeting the chemical requirements of Table 1 and mechanical properties of Table 2 but otherwise conforming to AWS A5.29 to reduce the number of performance qualifications?

Reply: It is the opinion of the Committee that welding filler metal meeting the chemical requirements of Table 1 and mechanical properties of Table 2 but otherwise conforming to AWS A5.29 may be considered as an F-No. 6 for performance qualifications only. Separate procedure qualifications are required.

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

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.08–0.13
Manganese	0.70–1.3
Phosphorus, max.	0.015
Sulfur, max.	0.015
Silicon	0.15–0.25
Chromium	8.5–10.5
Molybdenum	0.85–1.20
Vanadium	0.18–0.30
Nickel, max.	0.40
Columbium	0.02–0.040
Aluminum, max.	0.01
Copper, max.	0.40
Nitrogen	0.03–0.055
Cobalt, max.	0.6

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

Tensile strength, min., ksi	90
Elongation in 2 in., min. %	17

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Case 2300
Use of SA-372 Grade E Class 55, Grade J Class 55, and Grade F, G, and H Class 55 and 65 Forgings, Quenched and Tempered

Section VIII, Division 1

Approval Date: September 23, 1999

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

Inquiry: May liquid-quenched and tempered forging material complying with SA-372 Grade E Class 55, Grade J Class 55, and Grade F, G, and H Class 55 or 65 be used for pressure vessels fabricated by forging in construction under Section VIII, Division 1?

Reply: It is the opinion of the Committee that liquid-quenched and tempered forging material as described in the inquiry may be used for pressure vessels fabricated by forging in construction under Section VIII, Division 1, provided the following additional requirements are met:

(a) The rules in Section VIII, Division 1, Subsection B, that apply are those given in Part UF.

(b) The maximum allowable stress values for the materials shall be those given in Table 1. The stress values apply to quenched and tempered material only, as per the specification.

(c) This material shall not be used for external pressure design.

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

Table 1
Maximum Allowable Stress Values

Nominal Composition	Grade	Specified Min. Yield, ksi	Specified Min. Tensile, ksi	Maximum Allowable Stress Values, ksi for Metal Temperatures of 100–600°F
1Cr–$^1/_5$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.

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Case 2304-2
Austenitic Fe-35Ni-27Cr Alloy (UNS S35045)

Section I; Section VIII, Division 1

Approval Date: May 12, 2004

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

Inquiry: May annealed austenitic Fe-35Ni-27Cr alloy (UNS S35045) wrought sheet, strip, plate, rod, bar, seamless and welded pipe and tube, fittings, and forgings, with the chemical analysis shown in Table 1 and minimum mechanical properties shown in Table 2 and otherwise conforming to one of the specifications given in Table 3, be used in welded construction under the rules of Section I and Section VIII, Division 1?

Reply: It is the opinion of the Committee that material described in the Inquiry may be used in Section I and Section VIII, Division 1 construction at a design temperature of 1,650°F (900°C) or less, provided the following additional requirements are met:

(a) The rules in Section VIII, Division 1 that shall apply are those given in Part UNF for nickel alloys.

(b) For Section I design the y values (see PG-27.4 notes) used for PG-27.2.2 shall be as follows:

≤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.

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Case 2318
Alternative Flanged Joint Design for Nuclear Material Fluidized Bed Reactors

Section VIII, Division 1

Approval Date: September 23, 1999

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

Inquiry: Under what conditions may a vessel for nuclear material fluidized bed reactors intended for lethal service use a slip-on flange as a body flange?

Reply: It is the opinion of the Committee that a vessel for nuclear material fluidized bed reactors intended for lethal service may use a slip-on flange as a body flange provided all of the following conditions are met:

(a) The vessel does not exceed NPS 6 or 0.280-in. nominal wall thickness.

(b) The material is limited to N06600.

(c) Final weld surfaces are liquid penetrant examined in accordance with Appendix 8 of UW-2(a)(1)(-b).

(d) The flange is welded as shown in Appendix 2, Fig. 2-4(10a) of UW-2(a)(1)(-b).

(e) The maximum allowable working pressure does not exceed 150 psig.

(f) The maximum allowable working pressure shall not exceed 1000°F.

(g) The User shall stipulate to the Manufacturer that

(1) the vessel is operated within an engineered enclosure providing secondary containment

(2) the enclosure shall be maintained at a negative pressure during all modes of operation

(3) the enclosure shall be equipped with redundant leak detectors inside with both local and remote alarms

(4) the process shall be shut down if a detector is actuated

(h) The User shall stipulate to the Manufacturer that a hazard analysis will be conducted by an engineer experienced in the applicable analysis methodology that examines all credible scenarios that could result in a leak. The User shall also stipulate to the Manufacturer that the enclosure shall be designed to contain the contents from a leak. The results of the analysis shall be documented and signed by the individual identified to be in charge of the operation of the vessel.

(i) The User shall stipulate to the Manufacturer that documentation of the hazard analysis shall be made available to the regulatory and enforcement authorities having jurisdiction at the site where the vessel will be installed. The User of this Case is cautioned that prior jurisdictional acceptance may be required.

(j) Pressure testing in accordance with UG-99(c) is required.

(k) Provisions of this Case apply only to nonreactor nuclear facilities.

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

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Case 2321-1
Exemption From Postweld Heat Treatment for P-No. 4 or P-No. 5A Tube-to-Tubesheet Seal Welds

Section VIII, Division 1

Approval Date: February 20, 2002
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may tube-to-tubesheet seal welds between P-No. 4 or P-No. 5A tubes and P-No. 8 or P-No. 4X cladding on P-No. 1 tubesheets be exempt from postweld heat treatment requirements of UCS-56?

Reply: It is the opinion of the Committee that tube-to-tubesheet seal welds between P-No. 4 or P-No. 5A tubes and P-No. 8 or P-No. 4X cladding on P-No. 1 tubesheets may be exempted from postweld heat treatment requirements of UCS-56 under the following limitations:

(a) The P-No. 4 or P-No. 5A tubes shall have a wall thickness less than or equal to 0.150 in.

(b) The tubes are seal welded to the face of the cladding using the GTAW process.

(c) The cladding is deposited using F-No. 4X filler metal or deposited using F-No. 6 filler metal having a deposit chemistry of A-No. 8.

(d) The filler metal used to weld the tubes to P-No. 4X cladding is F-No. 4X filler metal. The filler metal used to weld the tubes to the P-No. 8 cladding is F-No. 4X or F-No. 6 filler metal having a deposit chemistry of A-No. 8.

(e) The vessel is not for lethal [UW-2(a)] service applications.

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

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Case 2324-1
Use of Automated Ultrasound Leak Detection System in Lieu of Visual Inspections Required by UG-100(d)

Section VIII, Division 1

Approval Date: March 21, 2012

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

Inquiry: Under what conditions may an automated ultrasound monitored leak detection system be used in lieu of the visual inspections required by UG-100(d)?

Reply: It is the opinion of the Committee that an automated ultrasound monitored leak detection system may be used in lieu of the visual inspections required by UG-100(d), provided that all of the following requirements are met:

(a) The materials of construction shall be P-No. 1 Group 1 or Group 2 and the weld thickness shall not exceed $^3/_8$ in. The vessel will not contain a "lethal" substance.

(b) The vessel design pressure shall not exceed 350 psi. The vessel shall be pressurized pneumatically, and the pressure in the vessel during the leak test shall meet the requirements of UG-100(d). All weld seams, which will be hidden by assembly, shall be given a visual examination for workmanship prior to assembly.

(c) The test shall be performed in an acoustically sealed chamber that is monitored by an array of ultrasound transducers capable of detecting the high-frequency emissions (20 kHz and higher) produced by a leak in the pressure vessel being tested. The ultrasound sensors shall be positioned so that the entire pressure vessel is monitored following the pressurization to detect leakage. The detection of any leakage shall be cause for rejection.

(d) The automated ultrasound leak inspection shall be monitored in accordance with a written procedure that includes the following:

(1) Calibrations of the airborne ultrasound leak detection system shall be conducted in accordance with methods and criteria of ASTM E1002-11 test method A, pressurization.

(2) A test shall be performed once each shift to verify the operation of the entire system. The test must confirm the ultrasound arrays are working properly and confirm the operability of any vessel routing sensors, conveyors, and related devices. This test shall be performed using a white noise to simulate a leak. Date, time, and operator initials confirming acceptance shall be recorded.

(3) The white noise calibration shall be validated at least once per month by demonstrating the system's ability to detect a leak through a 0.001 in. test orifice installed in a vessel.

(4) The manufacturer shall certify that personnel performing the calibration testing have been qualified and certified in accordance with their employer's written practices. The qualification records of certified personnel shall be maintained by their employer.

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

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Case 2327-4
9Cr-1Mo-1W-Cb Material

(25)

Section I

Approval Date: February 3, 2025

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

Inquiry: May the following 9Cr-1Mo-1W-Cb steel products be used in Section I construction?

(a) seamless tubes and pipes, seamless fittings, forgings, and plates conforming to the specifications listed in Table 1

(b) forged and bored pipes, with the chemical analysis shown in Table 2, the minimum mechanical properties shown in Table 3, and otherwise conforming to SA-369

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

(a) The material shall be austenitized within the temperature range of 1,900°F to 1,975°F (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.

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Case 2334
Single Fillet Lap Joints in the Shell of a Shell-and-Tube Heat Exchanger

Section VIII, Division 1

Approval Date: July 10, 2000
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a single fillet lap joint weld be used to join a cast tubesheet with flange extension to the shell in a shell-and-tube heat exchanger?

Reply: It is the opinion of the Committee that a single fillet lap joint weld may be used to join a cast tubesheet with flange extension to the shell in a shell-and-tube heat exchanger provided the following requirements are met.

(a) Outside diameter of the shell shall not exceed 12 in., and the nominal thickness of the shell (t_s) shall not exceed $^1/_4$ in.

(b) The fillet weld shall be attached on the outside and shall be examined by either magnetic particle or liquid penetrant methods after welding. The fillet weld shall meet the minimum cross-sectional requirements shown in Figure 1. A joint efficiency of 0.45 shall be used for this joint.

(c) MAWP on the shell side or the tube side shall not exceed 250 psig.

(d) Maximum design metal temperature (MDMT) shall not exceed 450°F.

(e) MDMT stamped on the nameplate shall not be colder than −20°F.

(f) Cyclic loading is not a controlling design requirement (see UG-22).

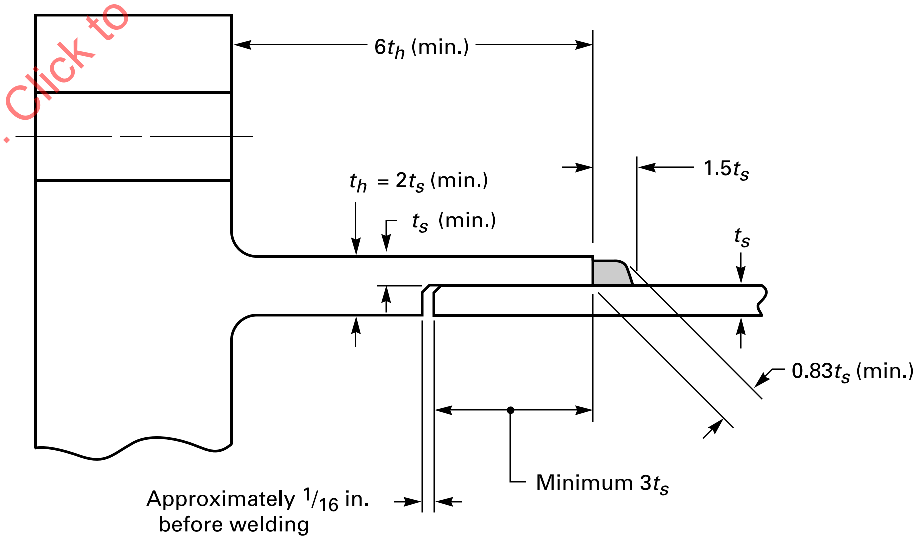
(g) The heat exchanger is not in lethal service (see UW-2).

(h) The tubesheet shall be supported such that at least 80% of the pressure load on the tubesheet is carried by tubes, stays, or braces.

(i) The tubesheet shall be a casting that has an integral flange and shell hub. The shell hub shall extend at least six times the hub thickness beyond the back of the tubesheet and meet the dimensional requirements of Figure 1. The casting material shall be either P-No. 1 or 8, or per UNF-8.

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

Figure 1



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Case 2346-1
Alternative Rules for Ellipsoidal or Torispherical Heads Having Integral Backing Strip Attached to Shells

Section VIII, Division 1

Approval Date: February 14, 2003

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

Inquiry: Under what conditions may ellipsoidal or torispherical heads having an integral backing strip be attached to shells?

Reply: It is the opinion of the Committee that an ellipsoidal or torispherical head having an integral backing strip be attached to shells provided the following requirements are met.

(a) MAWP on the vessel shall not exceed 470 psig.

(b) Maximum design metal temperature shall not exceed 400°F.

(c) MDMT stamped on the nameplate shall not be colder than −20°F.

(d) Cyclic loading is not a controlling design requirement (see UG-22).

(e) The vessel is not in lethal service (see UW-2).

(f) The straight flange (skirt) of the head is machined to form an integral backing strip meeting the requirements of Figure 1.

(g) Outside diameter of the formed head and shell shall not exceed 30 in. and the overall vessel length shall not exceed 96 in.

(h) The required thickness of the formed head shall not exceed $^5\!/_8$ 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.

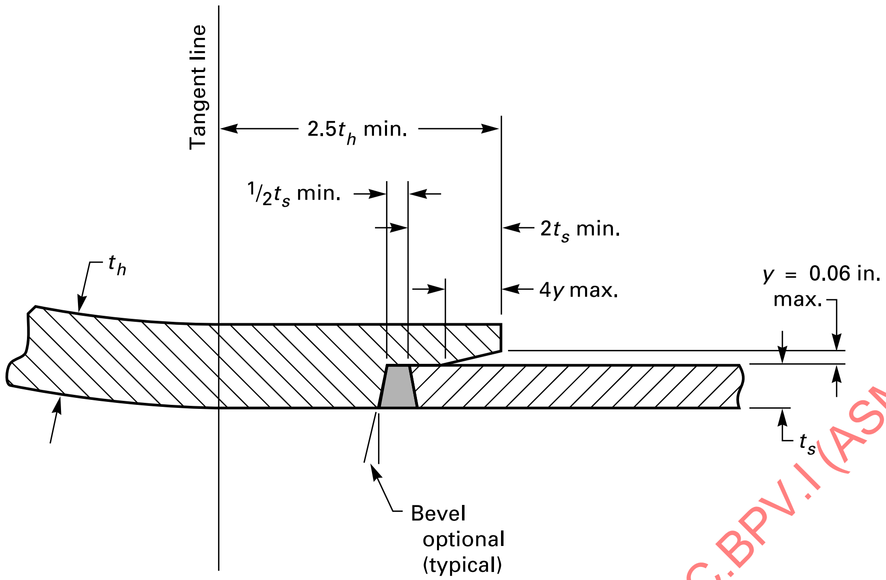
(l) The materials of construction shall be P-No. 1, Group 1 or 2.

(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.
$^1/_2 t_s$ min.
2t_s min.
4y max.
t_h
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.

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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.			
	$T \le 1\frac{1}{2}$	$1\frac{1}{2} < T \le 2\frac{1}{2}$	$2\frac{1}{2} < T \le 4$	$4 < T \le 6$
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			
	$T \le 38$	$38 < T \le 64$	$64 < T \le 100$	$100 < T \le 150$
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, ×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, ×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.

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Case 2357-2
Ni-Fe-Cr Alloy N08801 for Water-Wetted Service

Section I

Approval Date: December 30, 2006

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

Inquiry: May nickel-iron-chromium alloy N08801, seamless condenser and heat exchanger tubes and seamless pipe and tubes conforming to SB-163 and SB-407 be used in water-wetted service construction in Section I?

Reply: It is the opinion of the Committee that nickel-iron-chromium alloy forms as described in the Inquiry may be used in construction under Section I for water-wetted service, provided the following requirements are met:

(a) The material will be given a 1,725°F (940°C) to 1,825°F (995°C) stabilizing heat treatment.

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

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

(d) Welds that are exposed to the effects of corrosion should be made using a filler material having a corrosion resistance comparable to that of the base metal.

(e) Heat treatment after forming or fabrication is neither required nor prohibited, but if performed shall be in accordance with (a).

(f) The required thickness for external pressure shall be determined from the chart in Fig. NFN-9 of Section II, Part D.

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

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

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Case 2359-2
Ni-25Cr-9.5Fe-2.1Al Alloy (UNS N06025)

Section I; Section VIII, Division 1

Approval Date: June 23, 2005
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May solution annealed Ni-25Cr-9.5Fe-2.1Al Alloy (UNS N06025) wrought forgings, bar (up to 4 in. in diameter), plate, sheet, strip, welded pipe, seamless pipe and tube, and welded tube and fittings with chemical composition conforming to Table 1, mechanical properties conforming to Table 2, and otherwise conforming to the requirements of Specifications SB-163, SB-166, SB-167, SB-168, SB-366, SB-462, SB-516, SB-517, and SB-564 as applicable, be used in Section I for steam service and in Section VIII, Division 1 construction?

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

(a) For Section I use, the *y* values [see Section I, para. PG-27.4, Note (6)] shall be as follows:

(1) 1,050°F and below: 0.4
(2) 1,100°F: 0.5
(3) 1,150°F and above: 0.7

(b) The rules of Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for nickel alloys.

(c) For external pressure design use Section II, Part D, Fig. NFN-13 for temperatures not exceeding 1,200°F. The external pressure charts do not account for reduction of buckling strength due to creep under long-term loads. The effect of creep on buckling shall be considered at temperatures for which allowable stresses are shown in italics in Table 3.

(d) The maximum allowable stress values for the material shall be those given in Table 3.

(e) For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

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

(g) Heat treatment after welding or fabrication is neither required nor prohibited.

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

Table 1
Chemical Requirements

Element	Composition, %
Nickel	Balance
Chromium	24.0–26.0
Iron	8.0–11.0
Aluminum	1.8–2.4
Carbon	0.15–0.25
Silicon, max.	0.50
Sulfur, max.	0.010
Phosphorus, max.	0.020
Yttrium	0.05–0.12

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength, min., ksi	98
Yield strength, 0.2% min., ksi	39
Elongation in 2 in., min., %	30

Table 3
Maximum Allowable Stress Values

(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.

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Case 2385-1
37Ni-30Co-28Cr-2.75Si Alloy (UNS N12160)

Section VIII, Division 1

Approval Date: May 4, 2004

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

Inquiry: May annealed alloy UNS N12160 wrought sheet, strip, plate, rod, welded pipe and tube, wrought fittings, seamless pipe and tube, wrought fittings, seamless pipe and tube, and forgings, which meet the requirements of the specifications listed in Table 1, be used in welded construction under Section VIII, Division 1 above 1,500°F?

Reply: It is the opinion of the Committee that annealed alloy UNS N12160 wrought sheet, strip, plate, rod, welded pipe and tube, wrought fittings, seamless pipe and tube, and forgings as described in the Inquiry, may be used in the construction of welded pressure vessels complying with the rules of Section VIII, Division 1 above 1,500°F, providing the following additional requirements are met:

(a) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for nickel alloys.

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

(c) Welding shall be limited to GTAW and GMAW processes using filler metal with the same nominal composition as the base metal. The nominal thickness of the material at the weld shall not exceed 0.5 in.

NOTE: Thickness limitation is due to solidification cracking in sections greater than 0.5 in.

(d) Heat treatment after forming or welding is neither required nor prohibited. When heat treatment is to be employed, the requirements of UNF-56(b) shall apply.

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

Table 1
Product Specifications

Sheet, plate, and strip	SB-435
Rod	SB-572
Wrought fittings	SB-366
Forgings	SB-564
Seamless pipe and tube	SB-622
Welded pipe	SB-619
Welded pipe	SB-626

Table 2
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress, ksi [Note (1)] – [Note (4)]
1,550	1.8
1,600	1.5
1,650	1.3
1,700	1.0
1,750	0.85
1,800	0.73

NOTES:
(1) Stresses are values obtained from time-dependent properties.
(2) The criteria used to establish allowable stresses at design temperatures above 1,500°F included consideration of the F_{avg} factor as defined in Appendix 1 of Section II, Part D.
(3) Creep-fatigue, thermal ratcheting, and environmental effects are increasingly significant failure modes at temperatures in excess of 1,500°F and shall be considered in the design.
(4) Allowable stress values up to and including 1,500°F are in Section II-D, Table 1-B.

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Case 2397-2
Pressure Relief Valves That Exceed the Capability of Testing Laboratories

Section I

Approval Date: August 30, 2022
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: If a valve design exceeds the size, capacity, or pressure capability of an ASME-accepted testing laboratory, what alternative requirements to Section I, PG-69, Capacity Certification Testing, and Section I, PG-73 or Section VIII, Division 1, UG-136, Minimum Requirements, may be followed?

Reply: It is the opinion of the Committee that if a valve design exceeds the size, capacity, or pressure capability of an ASME-accepted testing laboratory the requirements of Section I, PG-67 through PG-73 and PG-110 shall be met with the following exceptions:

(a) For Section I, PG-69

(1) If the design exceeds the laboratory pressure capability, Section I, PG-69.2.2 or PG-69.2.3 shall be followed with the exception that the valves will be tested with their disks fixed at the minimum design lift to establish the rated capacity.

(2) If the design exceeds the laboratory size or capacity capability, Section I, PG-69.2.3 shall be followed with the exception that flow models of three different sizes, each tested at three different pressures, shall be used in place of valves required in Section I, PG-69.2.3 (a). Such flow models shall be sized consistent with the capabilities of the accepted test laboratory, where the test will be conducted and shall accurately model those features that affect flow capacity, such as orifice size, valve lift, and internal flow configuration. The test models need not be functional pressure relief valves, but shall be geometrically similar to the final product.

(3) In either case of subpara. (1) or (2) above, the valve design (i.e., parameters such as spring properties, seat geometry, and mechanical valve lift) shall be evaluated to ensure that production valves will achieve design lift as modeled above.

(b) For Section I, PG-73.4.3, the requirements of either subpara. (1) or (2) below shall be met:

(1) In lieu of the test requirements of Section I, PG-73.4.3:

(-a) two production valves that are representative of the design shall be tested per PTC 25, Part III (edition adopted by the governing Code Section), to demonstrate to the satisfaction of the representative of the ASME designated organization that:

(-1) The measured set pressure is consistent with the stamped set pressure within the tolerances required by Section I, PG-72.2.

(-2) The valve will achieve the minimum lift for its certified capacity.

(-3) The valve will operate without chatter or flutter. If only one valve of the design will be produced within the six-year period within which the permission is granted, only that valve need be tested as stated above.

(-b) The testing shall be performed at a facility that is mutually agreeable to the manufacturer, the representative of an ASME-designated organization, and the facility owner. The facility shall be capable of demonstrating the characteristics stated above.

(-c) In the event of failure of the tests, the manufacturer shall submit a written explanation to the ASME designated organization stating the cause and the corrective action taken to prevent recurrence followed by a repeat of the demonstration tests.

(2) The test requirements of Section I, PG-73.4.3 are followed using two functional models that are representative of the design in lieu of the production samples and the additional following tests are satisfactorily completed:

(-a) two production valves that are representative of the design shall be tested per PTC 25, Part III (edition adopted by the governing Code Section), to demonstrate to the satisfaction of the representative at the ASME designated organization that:

(-1) The measured set pressure is consistent with the stamped set pressure within the tolerances required by Section I, PG-72.2.

(-2) Seat tightness and a secondary pressure-zone leakage test are demonstrated in accordance with Section I, PG-73.5.3.

If only one valve of the design will be produced within the six-year period within which the permission is granted, only that valve need be tested as stated above.

(-b) The testing shall be performed at a facility that is mutually agreeable to the manufacturer, the representative of an ASME-designated organization, and the facility

owner. The facility shall be capable of demonstrating the characteristics stated above.

(-c) In the event of failure of the tests, the manufacturer shall submit a written explanation to the ASME designated organization stating the cause and the corrective action taken to prevent recurrence followed by a repeat of the demonstration tests.

(-d) After initial permission is granted in accordance with Section I, PG-73.4.3, permission may be extended for six-year periods if the tests of production samples are successfully completed in accordance with subparas. (-a) through (-c) above.

(c) This Case number shall be included with the marking information required in Section I, PG-110 and on Form P-8 for the valve, as applicable.

Case 2400
Alternative Rules for the Postweld Heat Treatment of Finned Tubes

Section VIII, Division 1

Approval Date: February 14, 2003
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May electric resistance welded fins be exempt from the postweld heat treatment requirements of Table UHA-32 for P-No. 7 base materials?

Reply: It is the opinion of the Committee that it is not necessary that electric resistance welds used to attach extended heat absorbing surfaces to tubes be postweld heat treated provided the following requirements are met:

(a) The fin thickness is no greater than 0.125 in. (3.2 mm).

(b) The maximum carbon content of the base metal shall be restricted to 0.15%.

(c) The maximum outside pipe or tube diameter (excluding fins) shall be $4\frac{1}{2}$ 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.

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Case 2402-1
SA-995, UNS J92205, (CD3MN), Austenitic/Ferritic Duplex Stainless Steel

Section VIII, Division 1

Approval Date: September 25, 2012

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

Inquiry: May SA-995 UNS J92205 (CD3MN) solution annealed casting material be used in the construction of vessels under the rules of Section VIII, Division 1?

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

(a) The maximum allowable design stress values in tension shall be those listed in Table 1 and Table 1M.

NOTE: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See paras. A-340 and A-360 in Appendix A of Section II, Part D.

(b) Tensile, S_u, and yield strength, S_y, at temperature are shown in Table 2, 2M, 3, and 3M, respectively.

(c) For Section VIII external pressure design, Figure and Table HA-5 of Section II, Part D shall be used.

(d) Separate welding procedure qualifications and performance qualifications shall be conducted as prescribed in Section IX.

(e) Heat treatment after welding is neither required nor prohibited. However, if heat treatment is applied, the solution annealing treatment shall consist of heating to a minimum temperature of 2050°F and then quenched in water or rapidly cooled by other means.

(f) The rules in Section VIII, Division 1 that shall apply are those given in Subsection C, Part UHA for austenitic-ferritic duplex stainless steels.

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

Table 1
Maximum Allowable Stress Values In Tension For Metal Temperature of SA-995 Castings

For Metal Temperatures Not Exceeding, °F	Maximum Allowable Stress Values, ksi
100	25.7
150	25.7
200	25.7
250	25.2
300	24.6
400	24.3
500	24.3

Table 1M
Maximum Allowable Stress Values In Tension For Metal Temperature of SA-995 Castings

For Metal Temperatures Not Exceeding, °C	Maximum Allowable Stress Values, MPa
40	177
65	177
100	177
150	170
200	168
250	168
300	168 [Note (1)]

NOTE: (1) This value is provided for interpolation purposes only. The maximum temperature for this materials is 260 °C.

Table 2
Tensile Strength Values

For Metal Temperature Not Exceeding, °F	Tensile Strength, ksi
100	90.0
200	90.0
300	86.2
400	85.2
500	85.2

Table 2M
Tensile Strength Values

For Metal Temperature Exceeding, °C	Tensile Strength, MPa
40	621
65	621
100	621
150	594
200	587
250	587
300	587

Table 3
Yield Strength Values

For Metal Temperature Not Exceeding, °F	Yield Strength, ksi
100	60.0
200	53.9
300	47.9
400	44.5
500	42.3

Table 3M
Yield Strength Values

For Metal Temperature Not Exceeding, °C	Yield Strength, MPa
40	414
65	395
100	366
150	330
200	308
250	294
300	284

Case 2403
Aluminum Alloy (Aluminum-6.3Magnesium) for Code Construction

Section VIII, Division 1

Approval Date: February 13, 2003
Impending Annulment Date: October 1, 2025
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May aluminum alloy (Aluminum-6.3Magnesium), plate, sheet, bar, rod, and wire that meet the chemical and mechanical property requirements in Tables 1 and 2, respectively, and otherwise conforming to one of the specifications listed in Table 3, be used in Section VIII, Division 1 welded construction?

Reply: It is the opinion of the Committee that aluminum alloy (Aluminum-6.3Magnesium) plate, sheet, bar, rod, and wire, as described in the Inquiry may be used in Section VIII, Division 1 welded construction provided the following additional requirements are met.

(a) The rules in Section VIII, Division 1, Subsection C that shall apply are those given in Part UNF for aluminum alloys.

(b) The maximum allowable stress values for the material shall be those given in Table 4.

(c) Separate welding procedure and performance qualifications shall be conducted for the material in accordance with Section IX. The minimum tensile strength and elongation for weld procedure qualification shall be that given for the base metal product form.

(d) Heat treatment after welding is not permitted.

(e) This Case is not intended for material to be used for external pressure applications.

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

CAUTION: Prolonged elevated temperature exposure above 150°F may make this material susceptible to exfoliation, intergranular attack, or stress-corrosion cracking.

Table 1
Chemical Requirements

Element	Composition, %
Silicon, max.	0.4
Iron, max.	0.4
Copper, max.	0.10
Manganese	0.5–0.8
Magnesium	5.8–6.8
Zinc, max.	0.20
Titanium	0.02–0.10
Beryllium	0.0002–0.005
Other elements, each	0.05
Other elements, total	0.10
Aluminum	remainder

Table 2
Mechanical Property Requirements

Property	Product Form		
	Sheet	Plate	Bar/Rod/ Wire
Tensile strength, min., ksi	43.5	39.5	45.0
Yield strength (0.2% offset), min., ksi	21.0	18.0	22.5
Elongation, min, %	15.0	6.0	15.0

Table 3
Product Specifications

Product	Specification
Plate, sheet	SB-209
Bar, rod, wire	SB-211

Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Product Form		
	Sheet	Plate	Bar/Rod/ Wire
100	12.4	11.3	12.9

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

Case 2407
Pneumatic Test

Section VIII, Division 1

Approval Date: February 13, 2003

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

Inquiry: Is it permissible to use a pneumatic test in lieu of the hydrostatic test specified in ULT-99 for pressure testing of vessels constructed in accordance with the requirements of Section VIII, Division 1, Part ULT?

Reply: It is the opinion of the Committee that it is permissible to use a pneumatic test in lieu of the hydrostatic test specified in ULT-99 for pressure testing of vessels constructed in accordance with the requirements of Section VIII, Division 1, Part ULT, provided the following additional requirements are met:

(a) The vessel shall be pneumatically tested at ambient temperature for a minimum of 15 min.

(b) The pneumatic test shall be performed in accordance with UG-100, except that the ratio of stresses is not applied, and the test pressure shall be at least 1.2 times the internal design pressure at 100°F (38°C). In no case shall the pneumatic test pressure exceed 1.25 times the basis for calculated test pressure as defined in 3-2.

(c) The liquid penetrant examination required by ULT-57(b) shall be performed prior to the pneumatic test.

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

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

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Case 2411
Use of Polymer Material for Bolted Box Headers

Section IV

Approval Date: June 23, 2005

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

Inquiry: May the polymer composed of a polystyrene-modified polyphenylene ether reinforced with 30% glass fibers, be used as the material for a bolted box header in Section IV construction?

Reply: It is the opinion of the Committee that a polystyrene- modified polyphenylene ether reinforced with 30% glass fibers, by weight, may be used as the material for a bolted box header in Section IV "H" stamped construction, provided the following requirements are met:

1 GENERAL REQUIREMENTS

(a) The polymer material shall be in compliance with the ASTM material specification D4349-93 and shall be limited to the polymer with a classification designation of PPE210G30A40452G1125F11 in accordance with the ASTM D4349-93 specification. In addition, the polymer material shall be certified by the materials manufacturer, and a report of test results shall be furnished to the boiler manufacturer for each lot of material.

(b) The bolted box headers shall not be exposed to the products of combustion.

(c) The completed boiler shall be limited to hot water service.

(d) The maximum heat input to the completed boiler shall be limited to 400,000 Btu/hr (120 kW).

(e) The maximum allowable working pressure shall be limited to 30 psig (200 kPa).

(f) The maximum water temperature shall be limited to 115°F (45°C), which shall be noted in the ASME stamping and documented on the Manufacturer's Data Report.

(g) The maximum volume of the bolted box header shall be limited to 1.0 gal (3.7 L).

(h) The polymer box header shall not be repaired prior to the application of the ASME marking.

(i) The polymer box header shall have a permanently attached label stating, "No repairs are permitted to this polymer box header."

(j) The polymer box header shall be insulated from the tubesheet to which it is bolted.

(k) The polymer box header shall be permanently marked in a manner to provide traceability to the material manufacturer's report of test results and to the injection molding machine.

(l) The injection molding process shall be controlled by a written procedure in which all of the following process variables shall be considered essential:

(1) melt temperature

(-a) nozzle

(-b) front

(-c) middle

(-d) rear

(2) mold temperature

(3) drying time (average)

(4) drying time (maximum)

(5) moisture content (% maximum)

(6) back pressure

(7) screw speed

(8) shot size to cylinder size

A change in any of the essential variables shall require requalification of the written procedure per the test procedure specified below. The Authorized Inspector shall monitor compliance of the written procedure.

(m) Headers used for qualification testing shall not be used on Code stamped boilers.

(n) The use of regrind material is prohibited.

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

2 DESIGN QUALIFICATION

The maximum allowable working pressure of the bolted box header shall be established by the following procedure:

(a) One or more full-scale prototype headers shall be subjected to a cyclic pressure test followed by a hydrostatic qualification test.

(b) The temperature of the test fluid for all tests shall be 115°F (45°C), minimum.

(c) The pressure shall be cycled from atmospheric to the design pressure and back 30,000 times.

(d) Then the pressure in the same prototype header shall be applied at a uniform rate so that six times the MAWP is reached in not less than 1 min.

(e) Leaks are prohibited.

Table 1
Visual Acceptance Criteria

Defects	Definitions	Maximum
Black spots, brown streaks	Dark spots or streaks	None permitted
Blisters	Hollows on or in the part	Pressure side: none permitted; None Pressure side: $\frac{1}{8}$ in. (3 mm) max. diameter, max. density 1/sq. ft (1/0.1 sq. m), none less than 2 in. (50 mm) apart
Bubbles	Air entrapped in the part	$\frac{1}{8}$ in. (3 mm) max. diameter, max. density 4/sq. in. (4/650 sq. mm); $\frac{1}{16}$ in. (1.5 mm) max. diameter, max. density 10/sq. in. (10/650 mm)
Burn marks, dieseling	Charred or dark plastic caused by trapped gas	None permitted
Cracking, crazing	Any visible	None permitted
Delamination	Single surface layers flake off the part	None permitted
Discoloration	Similar to burn marks, but generally not as dark or severe	Acceptable
Flow, halo, blush marks	Marks seen on the part due to flow of molten plastic across the molding surface	Acceptable
Gels	Bubbles or blisters on or in the part due to poor melt quality	None permitted
Jetting	Undeveloped frontal flow	None permitted

(f) The Authorized Inspector shall verify the cyclic pressure test and shall witness the hydrostatic pressure test.

(g) The prototype need not be tested to destruction.

(h) The prototype header shall be weighed to an accuracy of 0.1 oz (2.8 g). The weight shall be recorded on the Manufacturer's Data Report, Supplementary Sheet, H-6.

(i) The prototype header shall be visually examined for imperfections. Classification and acceptance level of imperfections shall be according to Table 1.

3 PRODUCTION HEADERS

(a) Each header shall be examined internally and externally for imperfections. Classification and acceptance level of imperfections shall be according to Table 1.

(b) Each production header shall be weighed within an accuracy of 0.1 oz (2.8 g), and the weight shall not be less than 98.75% of the weight of the prototype unit.

(c) The first ten headers in a production run shall be examined for conformance with dimensions and tolerances shown on the design drawings. Any dimension failing outside the specified limit shall be cause for rejection.

(d) Every tenth header after the first ten headers in a production run shall be examined for conformance with dimensions and tolerances shown on the design drawings. Any dimension failing outside the specified limits shall be cause for rejection of that header and the previous nine headers.

4 PRODUCTION QUALIFICATION

(a) At least one header per 1000 duplicate headers shall be subjected to a cyclic pressure and hydrostatic qualification pressure test per the requirements listed above.

(b) The header to be used for this test shall be selected at random by the Authorized Inspector.

Case 2416
Use of 15Cr-5Ni-3Cu (UNS S15500)

Section VIII, Division 2

Approval Date: February 13, 2003

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

Inquiry: May martensitic precipitation hardened stainless steel 15Cr-5Ni-3Cu (UNS S15500) forgings complying with SA-705 Type XM-12 be used for pressure vessels constructed under Section VIII, Division 2?

Reply: It is the opinion of the Committee that martensitic precipitation hardened stainless steel forgings as described in the Inquiry may be used for pressure vessels constructed under Section VIII, Division 2 provided the following additional requirements are met:

(a) The material shall be in the H1100 condition.

(b) External pressure not permitted.

(c) The design stress intensity and yield values shall be those listed in Table 1.

(d) No welding is permitted.

(e) Exemption from impact testing is not permitted.

(f) This Case number shall be shown on the material certification, marking on the material, and on the Manufacturer's Data report.

Table 1
Yield Strength and Design Stress Intensity Values

For Metal Temperature Not Exceeding, °F	Yield Strength S_y, ksi	Design Stress Intensity S_m, ksi
100	115.0	46.7
200	107.1	46.7
300	103.2	46.2
400	100.5	44.7
500	98.1	43.5
600	95.4	42.4

GENERAL NOTE: Caution is advised when using this material above 550°F. After prolonged exposure above 550°F, the toughness of this material may be reduced See Appendix A, A-360 of Section II, Part D.

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Case 2418-2
SA-182, SA-240, SA-479, SA-789, SA-790, and SA-815 21Cr-5Mn-1.5Ni-Cu-N (UNS S32101) Austenitic-Ferritic Duplex Stainless Steel

Section VIII, Division 1

Approval Date: June 23, 2014

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

Inquiry: May solution annealed UNS S32101 wrought material conforming to the requirements of specifications SA-182, SA-240, SA-479, SA-789, SA-790, and SA-815, or meeting the requirements of Table 1 and mechanical properties of Table 2 and otherwise meeting the requirements of SA-182 be used in the construction of vessels under the rules of Section VIII, Division 1?

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

(a) For SA-182, the material meets the chemical analysis and minimum mechanical properties shown in Table 1 and Table 2, respectively.

(b) The maximum allowable design stress values in tension shall be those listed in Table 3 and Table 3M. The maximum applicable use temperature shall be 600°F (316°C).

(c) For external pressure design, Figure HA-5 and Table HA-5 of Section II, Part D shall be used.

(d) This material is assigned P-No. 10H, Group 1.

(e) The solution annealing temperature shall be 1,870°F (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.

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Case 2421
Single Fillet Lap Joint for Heat Exchanger Tube Welds

Section VIII, Division 1

Approval Date: May 21, 2003

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

Inquiry: Under what conditions may a Type (6), single fillet lap joint, be used for Category B joints in heat exchanger tubes in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that a Type (6) lap joint may be used for Category B joints in heat exchanger tubes provided the following requirements are met:

(a) The Type (6) joint is not allowed in heat exchangers where the tubes act as stays or for fixed-fixed tubesheets.

(b) The maximum design temperature shall not exceed 800°F (425°C).

(c) Neither cyclic loading nor tube vibration shall be a controlling design requirement. (See UG-22.)

(d) The vessel shall not be in lethal service.

(e) The joint efficiency to be used in the appropriate design equations shall be 0.45.

(f) The tube outside diameter shall not exceed 2 in. (50 mm).

(g) The nominal wall thickness of the tube shall not exceed $\frac{1}{8}$ in. (3 mm).

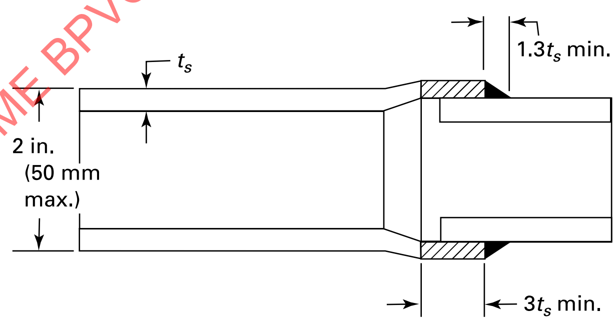
(h) The lap at the joint and the weld size shall meet the requirements of Figure 1.

(i) The joint shall have a pressed fit before welding.

(j) No tube forming is permitted at the joint after welding.

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

Figure 1



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Case 2426
Titanium Nickel-Molybdenum Ruthenium Alloy, Ti-0.8Ni-0.3Mo-0.1Ru

Section VIII, Division 1

Approval Date: January 27, 2003

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

Inquiry: May a Ti-0.8Ni-0.3Mo-0.1Ru alloy identical to ASME Grade 12 (UNS R53400) with 0.1 ruthenium added for corrosion enhancement may be used in Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that a Ti-0.8Ni-0.3Mo-0.1Ru alloy identical to ASME Grade 12 (UNS R53400) with 0.1 ruthenium added for corrosion enhancement may be used in Section VIII, Division 1 construction provided the following requirements are met:

(a) The material shall meet the chemical analysis shown in Table 1 and all other requirements of the corresponding specifications listed in Table 2.

(b) The material shall meet the minimum mechanical properties of Grade 12 in the respective specifications shown in Table 2.

(c) The maximum allowable stress values shall be as shown in Table 3.

(d) External pressure chart NFT-1 shall be used for the material.

(e) Separate welding procedure qualifications and welding performance qualifications conducted in accordance with the requirements of Section IX shall be required for these materials.

(f) All other rules for Section VIII, Division 1 applicable to titanium-nickel-molybdenum alloy Grade 12 (including F12, WPT12, and WPT12W) shall be met.

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

Table 1
Chemical Requirements

Element	Composition, %
Oxygen	0.25 max.
Iron	0.30 max.
Hydrogen	0.015 max.
Carbon	0.08 max.
Nitrogen	0.03 max.
Nickel	0.6–0.9
Molybdenum	0.2–0.4
Ruthenium	0.08–0.14
Residuals, each	0.1
Residuals, total	0.4
Titanium	Remainder

Table 2
Product Specifications

Product	Specification	Grade
Plate, sheet, strip	SB-265	12
Bar, billet	SB-348	12
Forgings	SB-381	F12
Seamless tube	SB-338	12
Welded tube	SB-338	12
Seamless pipe	SB-861	12
Welded pipe	SB-862	12
Seamless fittings	SB-363	WPT12
Welded fittings	SB-363	WPT12W

Table 3
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi [Note (1)]	
	Wrought	Welded Pipe and Tube [Note (2)]
−20 to 100	20.0	17.0
150	20.0	17.0
200	18.7	15.9
250	17.4	14.8
300	16.2	13.8
350	15.2	12.9
400	14.3	12.1
450	13.6	11.5
500	13.1	11.1
550	12.7	10.8
600	12.3	10.5

NOTES:
(1) Values are identical to the values for Grade 12 in ASME Section II, Part D, Table 1B.
(2) A joint efficiency of 85% has been used in determining the joint efficiency in welded pipe, fittings, and tube.

Case 2427
Chromium-Nickel-Molybdenum-Nitrogen-Tungsten Duplex Stainless Steel UNS S39274 Plate

Section VIII, Division 1

Approval Date: May 21, 2003
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may solution-annealed UNS S39274 plates be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that the material described in the Inquiry may be used in the construction of welded pressure vessels conforming to the rules of Section VIII, Division 1, provided the following additional requirements are met:

(a) The material meets the chemical requirement given in Table 1 and the minimum mechanical property requirements given in Table 2, and otherwise conforms to the requirements of SA-240.

(b) For Section VIII, Division 1 construction, the rules for austenitic-ferritic stainless steels in Subsection C, Part UHA, shall apply.

(c) The plates shall be solution annealed in the temperature range of 1920°F–2100°F (1050°C–1150°C) and shall then be quenched in water or rapidly cooled by other means.

(d) The maximum allowable stress values shall be as given in Table 3. The maximum design temperature is 650°F (345°C).

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

(f) Welding procedure and performance qualifications shall be performed in accordance with Section IX.

(g) Heat treatment after forming or fabrication is neither required nor prohibited. When heat treatment is performed, it shall be performed as noted in (c).

(h) Welding shall be done using the GTAW or SMAW process.

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

Table 1
Chemical Requirements

Element	Composition, %
Carbon	0.030 max.
Manganese	1.00
Phosphorus	0.030 max.
Sulfur	0.020 max.
Silicon	0.80 max.
Nickel	6.0–8.0
Chromium	24.0–26.0
Molybdenum	2.5–3.5
Nitrogen	0.24–0.32
Copper	0.20–0.80
Tungsten	1.50–2.50

Table 2
Mechanical Property Requirements (Room Temperature)

Tensile strength, min., ksi (MPa)	116	(800)
Yield strength, 0.2% offset, min., ksi (MPa)	80	(550)
Elongation in 2–in., (50 mm) gage length, min, %	15	...
Hardness, max.	310 HB or 32 HRC	...

Table 3
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi	For Metal Temperature Not Exceeding, °C	Allowable Stress Values, MPa
100	33.1	40	229
200	33.1	100	228
300	31.6	150	218
400	31.4	200	216
500	31.4	250	216
600	31.4	300	216
650	31.4	350	216 [Note (1)]

GENERAL NOTES:
(a) The revised criterion of 3.5 on tensile strength was used in establishing these values.
(b) The material embrittles after exposure at moderately elevated temperatures. See paras. A-340 and A-360 in Appendix A of Section II, Part D.

NOTE: (1) This value is provided for interpolation purposes only. The maximum design temperature for this material is as stated in (d).

Case 2428-4
Attachment of Tubes to Flat Tubesheets Using Complete Penetration Welds

Section VIII, Division 1

Approval Date: April 17, 2020
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions is it permissible to attach tubes to a flat tubesheet by welding when the tubes have partial or no penetration into the tubesheet for Section VIII, Division 1 construction?

Reply: It is the opinion of the Committee that it is permissible to attach tubes to a flat tubesheet by welding when the tubes have partial or no penetration into the tubesheet for Section VIII, Division 1 construction, provided the following requirements are met:

(a) The tube and tubesheet materials shall be restricted to P-No. 1, P-No. 3, or P-No. 4 materials.

(b) The materials shall not be used at temperatures exceeding the temperature limit for Section VIII, Division 1 shown in Section II, Part D, Subpart 1, Table 1A nor shall they be used at temperatures where the time-dependent properties govern.

(c) The weld joining the tube to the tubesheet shall be a full penetration weld made from the I.D. of the tube. (See Figure 1.) The throat of the weld shall be equal to or greater than the thickness of the tube. The root pass shall be made using the GTAW process.

(d) PWHT per UCS-56 is mandatory. The exemptions to PWHT noted in Table UCS-56 shall not apply.

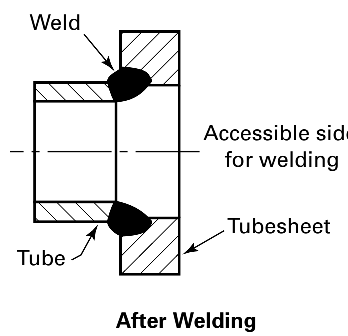
(e) The welding procedure specifications, the welders, and the welding operators shall be qualified in accordance with Section IX.

(f) In addition to meeting the performance qualification requirements of (e), before making a production weld each welder and welding operator shall demonstrate his or her ability to achieve complete weld penetration and minimum thickness by successfully welding six test pieces. The test pieces shall be welded in a mockup of the production weld. The mockup shall be of identical position, dimensions, and materials as that of the production weld. The test pieces shall be visually examined to verify complete penetration and sectioned to verify minimum required weld thickness. The results shall be recorded and maintained with the performance qualification record.

(g) Each weld surface on the tube I.D. shall receive either a magnetic particle or liquid penetrant examination in accordance with Section VIII, Division 1, Mandatory Appendix 6 or Mandatory Appendix 8, as applicable. In addition, a visual examination of the weld surface on the tube O.D. shall be performed. The maximum practicable number of these welds, but in no case fewer than 50%, shall be visually examined. Visual examination shall show complete penetration of the joint root and freedom from cracks.

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

Figure 1
Full Penetration Weld



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Case 2430
Use of A213/A213M-04 UNS S31060 Austenitic Stainless Steel Seamless Tubing and A240/A240M-04a$^{\varepsilon 1}$ 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 $66^2/_3$%, 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.

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 $66^2/_3$%, 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.

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

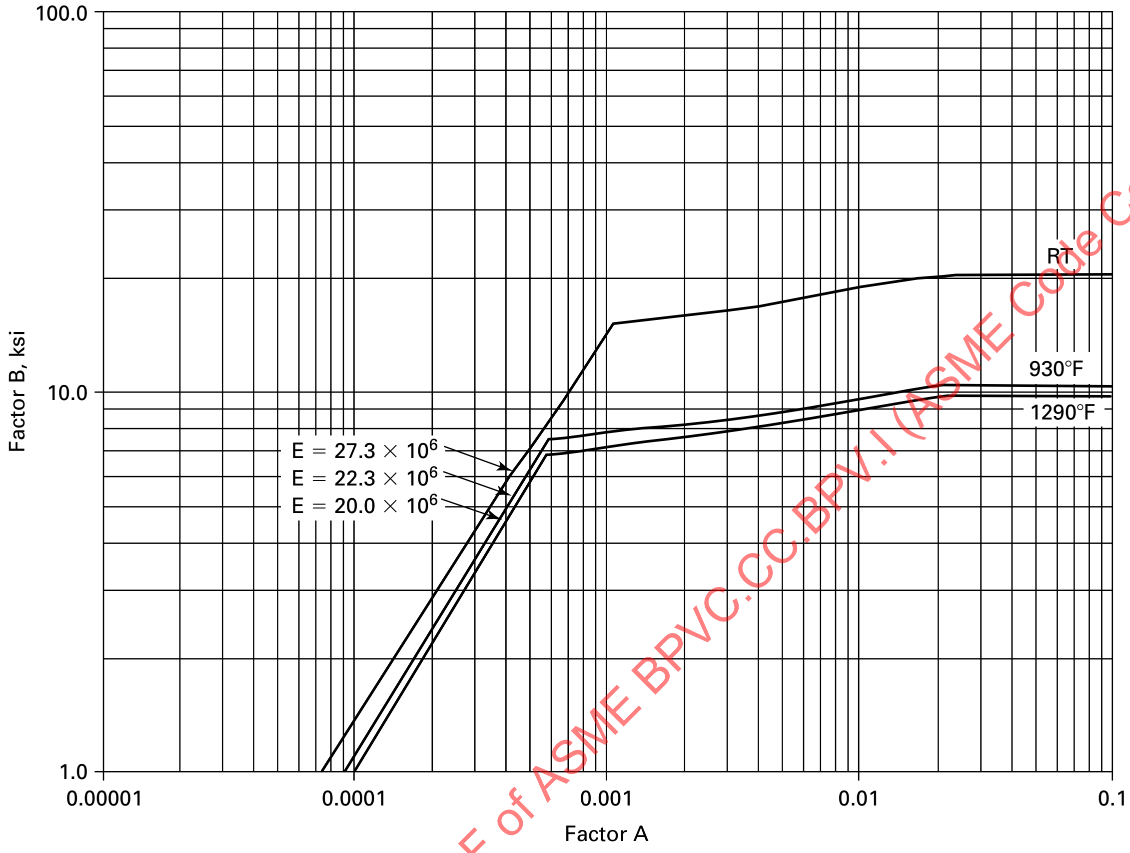

Figure 1M
Chart for Determining Shell Thickness of Components under External Pressure When Constructed of Alloy UNS S31060

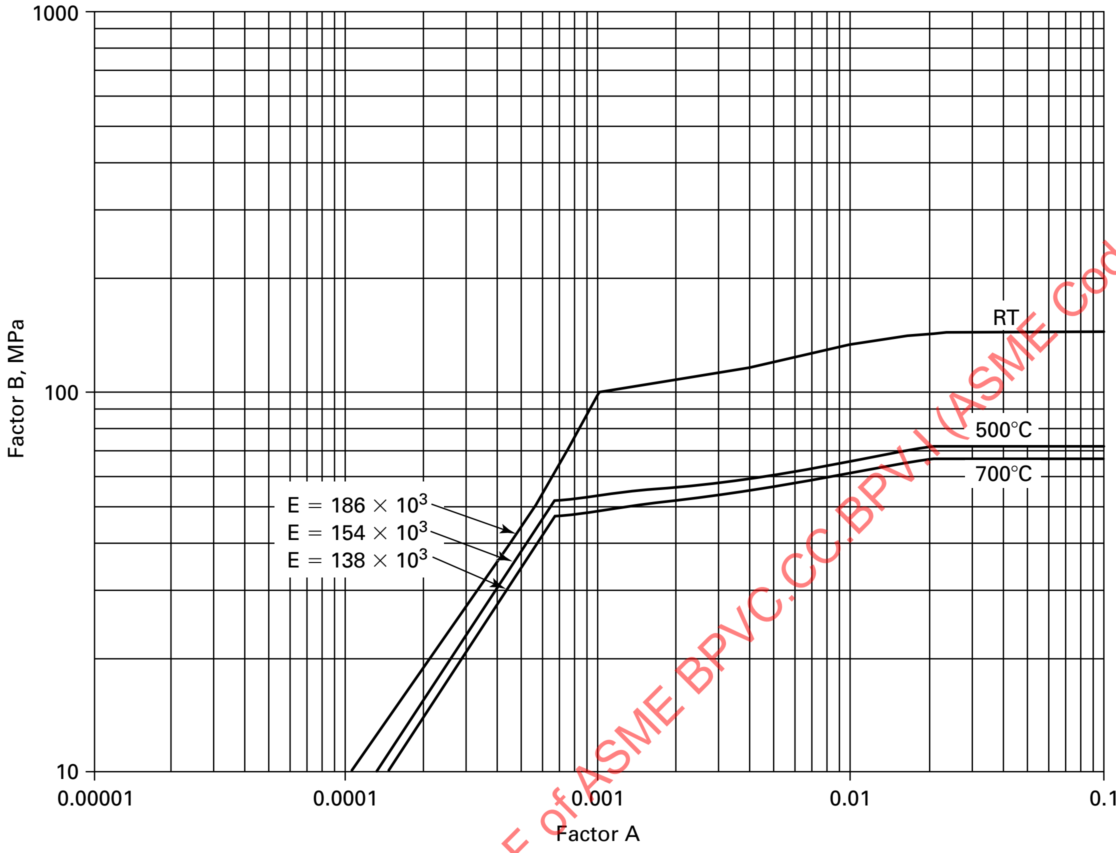

Table 2
Tabular Values for UNS S31060

Temp.,°F	Temp.,°C	A	B, ksi	B, MPa
RT	RT	7.33−05	1.0	6.9
		1.06−03	14.5	100.0
		3.00	16.0	110.3
		4.50	17.0	117.2
		6.85	18.0	124.1
		1.00−02	19.0	131.0
		1.75	20.0	137.9
		2.52	20.5	141.3
		1.00−01	20.5	141.3
930	500	8.97−05	1.0	6.9
		6.82−04	7.6	52.4
		1.50−03	8.0	55.2
		3.30	8.5	58.6
		5.70	9.0	62.1
		9.40	9.5	65.5
		1.50−02	10.0	69.0
		2.10	10.5	72.1
		1.00−01	10.5	72.1
1,290	700	1.00−04	1.0	6.9
		6.80	6.8	46.9
		1.80−03	7.5	51.7
		6.20	8.5	58.6
		9.90	9.0	62.1
		2.05−02	9.75	67.2
		1.00−01	9.75	67.2

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Case 2432-1
Use of 5052-H32, 6061-T6, and 6061-T651 Temper Aluminum Alloys in Part HF of Section IV, for Construction of Heating Boilers

Section IV; Section II, Part B

Approval Date: June 20, 2008

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

Inquiry: May aluminum alloys, 5052-H32, 5052-O, 6061-T6, and 6061-T651 be used in the construction of Section IV hot water heating boilers?

Reply: It is the opinion of the committee that 5052-H32, 5052-O, 6061-T6, and 6061-T651 aluminum alloys may be used for the construction of Section IV hot water heating boilers provided the following conditions are met:

(a) Materials shall conform to the specifications listed in Table 1 for the various product forms.

(b) The minimum allowable thickness shall be the same as that shown in Table HF-301.2 for copper, admiralty, and red brass.

(c) Maximum metal temperature shall not exceed 300°F (150°C).

(d) Maximum allowable stress values shall be as shown in Table 2, Table 2M, Table 3, and Table 3M.

(e) All other requirements of Section IV shall apply.

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

Table 1
Product Specifications

Product Form	Specification Number	UNS Number
Sheet and plate	SB-209	A95052/A96061
Drawn seamless tube	SB-210	A95052/A96061
Bar, rod, and wire	SB-211	A96061
Extruded bar, rod, and shape	SB-221	A96061
Seamless pipe and seamless extruded tube	SB-241/SB-241M	A95052/A96061

Table 2
Maximum Allowable Stress Values for Welded 5052 Aluminum

Specification Number	Temper	Specified Min. Tensile Strength, ksi	Specified Min. Yield Strength, ksi	Allowable Stress Values, ksi for Metal Temperature Not Exceeding, °F				
				−20 to 100	150	200	250	300
Sheet and Plate								
SB-209	H32 welded	25	9.5	5.0	5.0	5.0	4.7	4.5
Drawn Seamless Tube								
SB-210	H32 welded	25	10	5.0	5.0	5.0	4.7	4.5
Seamless Pipe and Seamless Extruded Tube								
SB-241/SB-241M	H32 welded	25	10	5.0	5.0	5.0	4.7	4.5
Drawn Seamless Tube								
SB-210	O brazed	25	10	5.0	5.0	5.0	4.7	4.5

Table 2M
Maximum Allowable Stress Values for Welded 5052 Aluminum

Specification Number	Temper	Specified Min. Tensile Strength, MPa	Specified Min. Yield Strength, MPa	Allowable Stress Values, MPa for Metal Temperature Not Exceeding, °C				
				−30 to 40	65	100	125	150
Sheet and Plate								
SB-209	H32 welded	172	69	34.5	34.5	34.5	34.5	32.8
Drawn Seamless Tube								
SB-210	H32 welded	172	69	34.5	34.5	34.5	34.5	32.8
Seamless Pipe and Seamless Extruded Tube								
SB-241/SB-241M	H32 welded	172	69	34.5	34.5	34.5	34.5	32.8
Drawn Seamless Tube								
SB-210	O brazed	172	69	34.5	34.5	34.5	34.5	32.8

Table 3
Maximum Allowable Stress Values for Welded 6061-T6 And 6061-T651 Aluminum

Specification Number	Temper	Specified Min. Tensile Strength, ksi	Specified Min. Yield Strength, ksi	Allowable Stress Values, ksi for Metal Temperature Not Exceeding, °F				
				−20 to 100	150	200	250	300
Sheet and Plate								
SB-209	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
	T651 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
Drawn Seamless Tube								
SB-210	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
Bar, Rod, Wire								
SB-211	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
…	T651 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
Extruded Bar, Rod, and Shapes								
SB-221	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4
Seamless Pipe and Seamless Extruded Tube								
SB-241/SB-241M	T6 welded	24	8.0	4.8	4.8	4.8	4.7	4.4

Table 3M
Maximum Allowable Stress Values for Welded 6061-T6 And 6061-T651 Aluminum

Specification Number	Temper	Specified Min. Tensile Strength, MPa	Specified Min. Yield Strength, MPa	Allowable Stress Values, MPa for Metal Temperature Not Exceeding, °C				
				−30 to 40	65	100	125	150
Sheet and Plate								
SB-209	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2
	T651 welded	165	55	33.1	33.1	33.1	32.6	31.2
Drawn Seamless Tube								
SB-210	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2
Bar, Rod, Wire								
SB-211	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2
	T651 welded	165	55	33.1	33.1	33.1	32.6	31.2
Extruded Bar, Rod, and Shapes								
SB-221	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2
Seamless Pipe and Seamless Extruded Tube								
SB-241/SB-241M	T6 welded	165	55	33.1	33.1	33.1	32.6	31.2

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Case 2439
Ni-Cr-Co-Mo Alloy (UNS N06617)

Section I

Approval Date: February 14, 2003

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

Inquiry: May solution annealed Ni-Cr-Co-Mo alloy (UNS N06617) wrought plate, rod, bar, forgings, and seamless tube that meet the requirements of the specifications listed in Table 1 be used in water wetted service in welded construction under Section I?

Reply: It is the opinion of the Committee that solution annealed Ni-Cr-Co-Mo alloy (UNS N06617) as described in the Inquiry may be used in the construction of welded pressure vessels under Section I, provided the following additional requirements are met.

(a) Material shall be solution annealed at a temperature of 2100–2250°F and quenched in water or rapidly cooled by other means.

(b) The materials shall conform to the specifications listed in Table 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 $66^2/_3$% 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 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 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 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 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 350°C.

Case 2446-1
Pilot-Operated Pressure Relief Valves for PG-67.2.1.6 Applications

(25)

Section I

Approval Date: November 10, 2024
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: Under what conditions may a pilot-operated pressure relief valve be used to satisfy the requirements of PG-67.2.1.6?

Reply: It is the opinion of the Committee that a pilot-operated pressure relief valve may be used to satisfy the requirements of PG-67.2.1.6, provided all of the following conditions are met:

(a) all requirements of PG-67 through PG-73 inclusive, as applicable for economizer overpressure protection.

(b) the pilot-operated pressure relief valve must be self-actuated and the main valve will open automatically at not over the set pressure and will discharge its full rated capacity if some essential part of the pilot should fail.

(c) the pilot-operated pressure relief valve shall be capacity certified for steam service per PG-69.

(d) the pilot-operated pressure relief valve shall be capacity certified for water service to the test requirements of PG-69.1 with the following exceptions:

(1) Set pressure and blowdown adjustment tests shall be performed using steam in accordance with PG-69.1.

(2) If the four-device method of Section XIII, 9.7.5 is used for incompressible fluids, the absolute flow-rating pressure P_f shall have a maximum pressure for capacity certification test of 103% of set pressure, or set pressure + 15 kPa (2 psi), whichever is greater.

(3) If the coefficient of discharge method of Section XIII, 9.7.6 is used for water or other incompressible fluids, the absolute relieving pressure P shall have a maximum pressure for capacity certification test of 103% of set pressure, or set pressure + 15 kPa (2 psi), whichever is greater.

(e) the nameplate shall be marked in accordance with PG-110. The set pressure shall be based on steam tests. In addition to the steam capacity in lbm/hr (kg/h), the nameplate shall be marked with water capacity in gal/min (L/min) at 70°F (20°C).

(f) this Case number shall be on a plate permanently attached to the valve.

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Case 2458-3
Austenitic Fe-27Ni-22Cr-7Mo-Mn-Cu-N Alloy (UNS S31277)

Section I; Section VIII, Division 1

Approval Date: January 22, 2007

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

Inquiry: May annealed austenitic Fe-27Ni-22Cr-7Mo-Mn-Cu-N Alloy (UNS S31277) wrought sheet, strip, plate, rod and bar, flanges and fittings, and seamless and welded pipe and tubing with chemical analysis shown in Table 1 and minimum mechanical properties shown in Table 2 and otherwise conforming to one of the specifications shown in Table 3, be used in welded construction under the rules of Section I for water wetted and steam service?

Reply: It is the opinion of the Committee that material described in the inquiry may be used in Section I construction at a design temperature of 800°F (427°C) or less, provided the following additional requirements are met:

(a) The maximum allowable stress values for material shall be those given in Tables 4 and 4M. The maximum design temperature shall be 800°F (427°C). For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

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

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

(d) For external pressure design, use Figures 1 and 1M and Tables 5 and 5M.

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

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

Table 1
Chemical Composition

Element	Composition, %
Carbon, max.	0.020
Manganese, max.	3.00
Phosphorus, max.	0.030
Sulfur, max.	0.010
Silicon, max.	0.50
Nickel	26.0–28.0
Chromium	20.5–23.0
Molybdenum	6.5–8.0
Copper	0.50–1.50
Nitrogen	0.30–0.40
Iron [Note (1)]	Balance

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

Table 2
Mechanical Property Requirements (All Product Forms)

Tensile strength, min.	112 ksi (770 MPa)
Yield strength, 0.2% offset, min.	52 ksi (360 MPa)
Elongation in 2 in. or 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

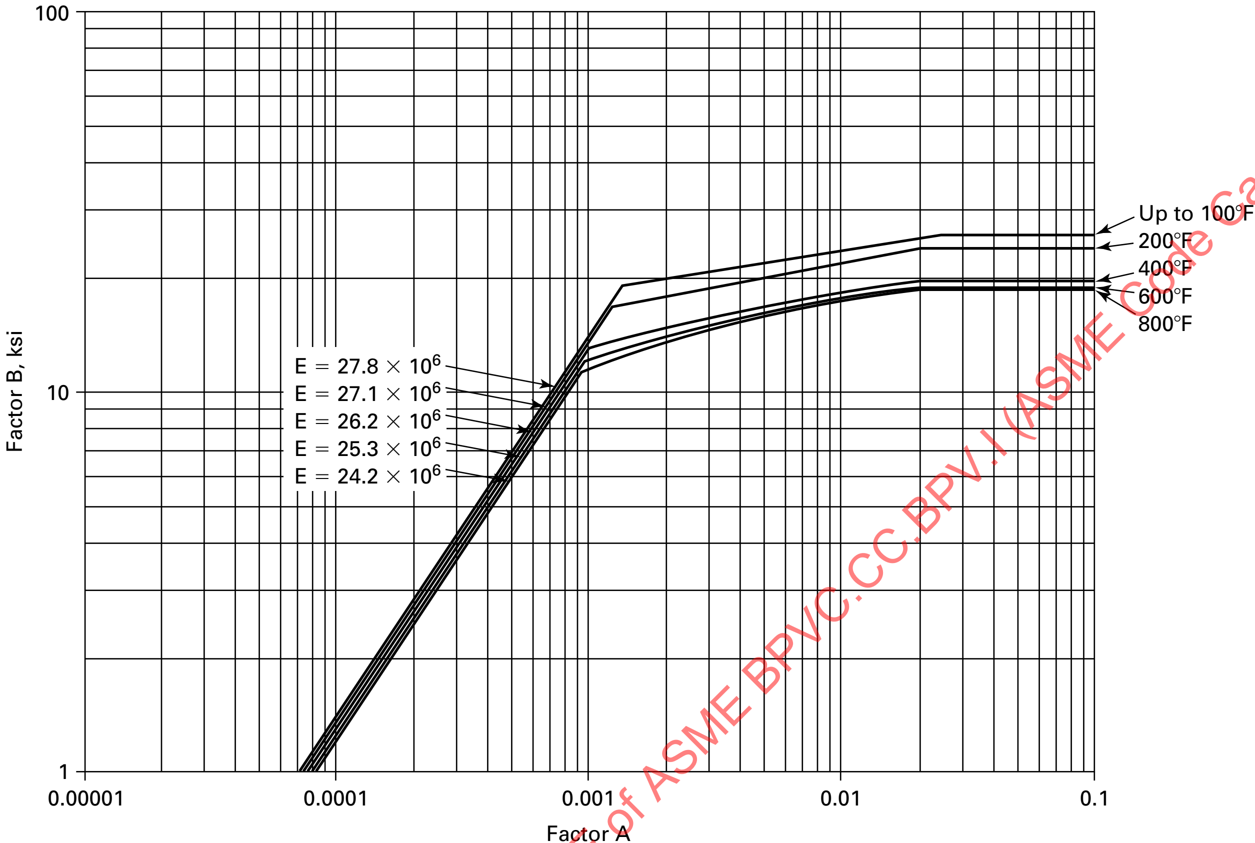
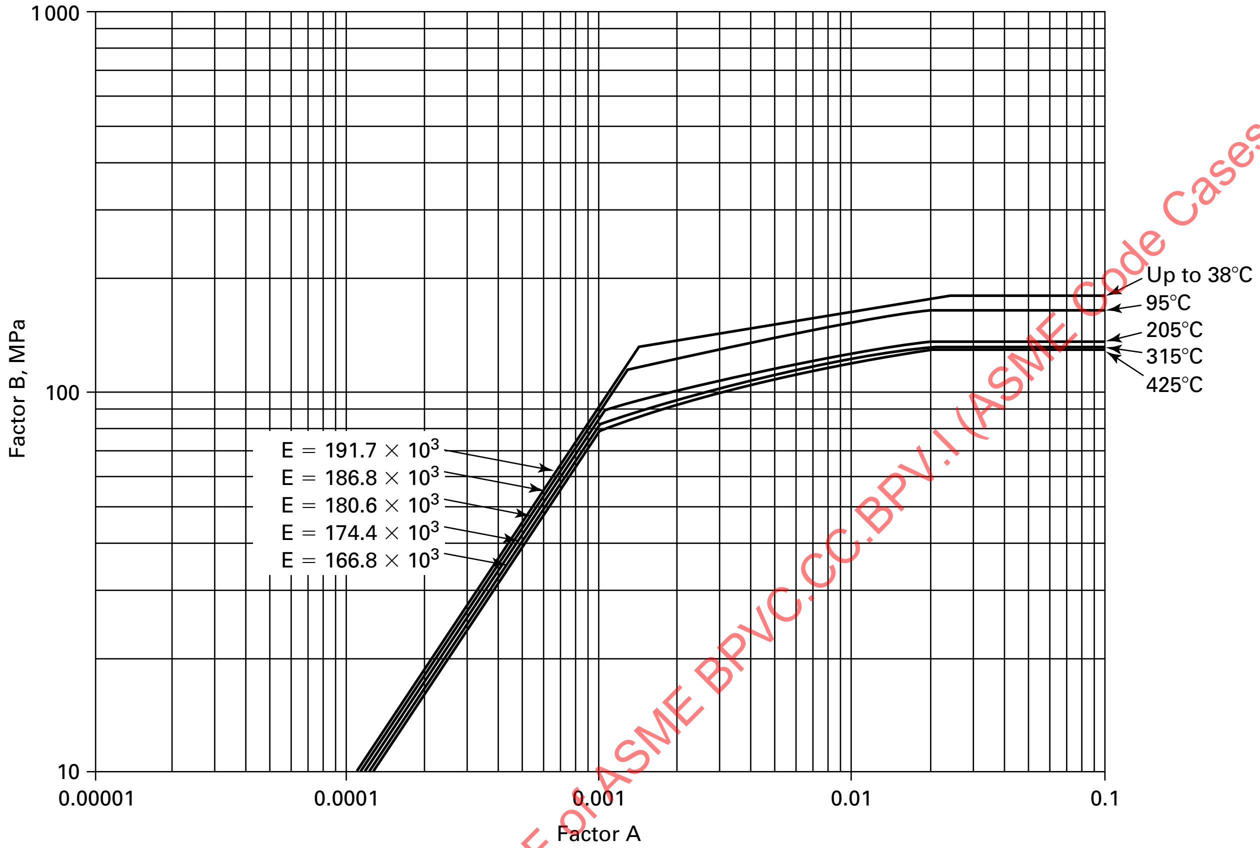


Figure 1M
Chart for Determining Shell Thickness of Components Under External Pressure When Constructed of Alloy UNS S31277



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Case 2461-2
Use of Chromium-Silicon Alloy Steel Wire for Pressure Vessel Winding

Section VIII, Division 3

Approval Date: September 12, 2017

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

Inquiry: May a flat hardened and tempered chromium-silicon alloy steel wire be used for winding of Section VIII, Division 3 pressure vessels constructed to the requirements of KD-9 and KF-9?

Reply: It is the opinion of the Committee that flat hardened and tempered chromium-silicon alloy steel wire may be used for winding of Section VIII, Division 3 pressure vessels, provided the wire conforms to SA-905 with the following exceptions:

(a) Materials and Manufacture

(1) The steel may be made by any commercially accepted steel making process. The steel shall be continuously cast.

(2) The finished wire shall be free from detrimental pipe and undue segregation.

(b) Chemical Analysis

(1) The steel shall conform to the requirements for chemical composition specified in Table 1.

(2) Heat Analysis. Each heat of steel shall be analyzed by the manufacturer to determine the percentage of elements prescribed in Table 1. This analysis shall be made from a test specimen preferably taken during the pouring of the heat. When requested, this shall be reported to the purchaser and shall conform to the requirements of Table 1.

(3) Product Analysis. An analysis may be made by the purchaser from finished wire representing each heat of steel. The average of all the separate determinations made shall be within the limits specified in the analysis column. Individual determinations may vary to the extent shown in the product analysis tolerance column, except that several determinations of a single element in any one heat shall not vary both above and below the specified range.

(4) For reference purposes, A751, Test Methods, Practices, and Terminology, shall be used.

(c) Metallurgical Requirements

(1) Decarburization

(-a) Transverse sections of the wire properly mounted, polished, and etched shall show no completely decarburized (carbon-free) areas when examined using 100× magnification. Partial decarburization shall not exceed a depth of 0.001 in. (0.025 mm).

(-b) Number of Tests. One test specimen shall be taken for each of five coils, or fraction thereof, in a lot.

(-c) Location of Tests. Test specimens may be taken from either end of the coil.

(2) Inclusion Content

(-a) The inclusion content of the wire rod in the worst case shall not exceed the limits shown in Table 2 as described in Test Method E45, Plate I-r, Method D, except that alternate methodologies are acceptable upon agreement between the purchaser and supplier, provided minimum requirements are not lower than those of Test Method E45, Method D.

(-b) If any coil exceeds the limits in Table 2, all coils in the lot will be inspected. Each coil that fails to meet the requirements will be rejected.

(-c) Number of Tests. One test specimen shall be taken for each group of 10 coils, or fraction thereof, in the lot.

(-d) Location of Tests. Test specimens may be taken from either end of the coil.

(-e) Test Method. Examination shall be made in accordance with Test Method E45.

(d) Final heat treatment shall consist of austenitizing, quenching, and tempering to achieve the required mechanical properties.

(e) Mechanical properties shall meet the properties given in Table 3.

(f) The nondestructive examination according to Supplementary Requirement S1 of SA-905 is mandatory.

(g) Yield strength values provided in Tables 4 and 4M shall be used for design.

(h) The design temperature shall not exceed 300°F (150°C). The designer is cautioned that stress relaxation might occur at design conditions permitted by this Code Case.

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

Table 1
Chemical Requirements

Element	Heat Analysis, %	Product Analysis Tolerance, %
Carbon	0.51–0.59	±0.02
Manganese	0.50–0.80	±0.03
Phosphorus	0.025 max.	±0.005
Sulfur	0.025 max.	±0.005
Silicon	1.20–1.60	±0.05
Chromium	0.60–0.80	±0.03

Table 2
Maximum Inclusion Content

	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

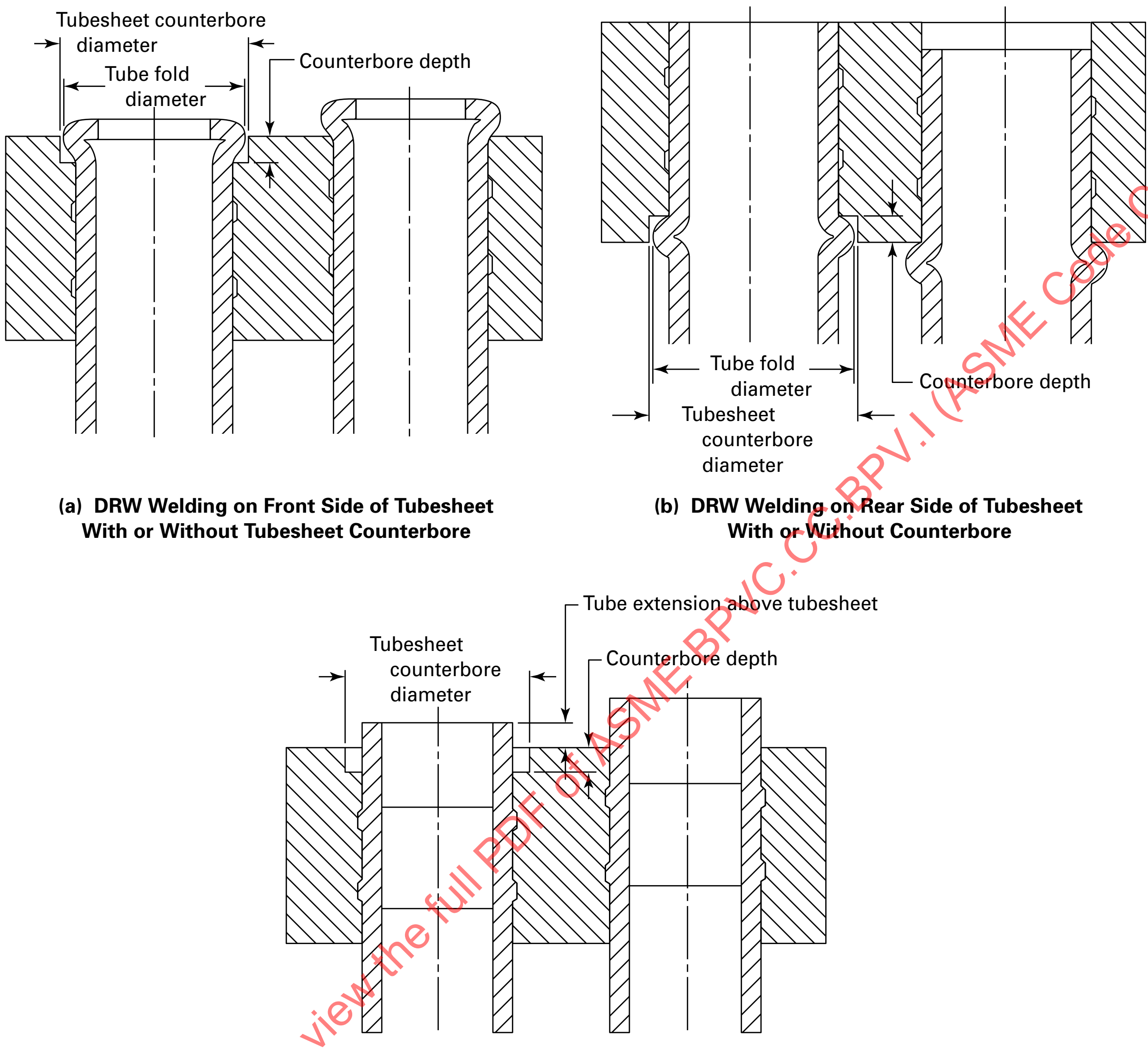
(i) a change of more than 5% in the pulse width from that qualified

(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.

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Case 2468-3
Use of Nickel-Chromium-Molybdenum-Columbium Alloy UNS N06625 for Class 2

Section VIII, Division 2

Approval Date: March 13, 2020

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

Inquiry: Under what conditions may UNS N06625 SB-443, Grade 1 (annealed) and Grade 2 (solution annealed) plate, sheet, and strip, SB-444 Grade 1 (annealed) and Grade 2 (solution annealed) pipe and tube, SB-446 Grade 1 (annealed) and Grade 2 (solution annealed) rod and bar, and SB-564 be used in Section VIII, Division 2, Class 2?

Reply: It is the opinion of the Committee that UNS N06625 SB-443 Grade 1 (annealed) and Grade 2 (solution annealed) plate, sheet, and strip, SB-444 Grade 1 (annealed) and Grade 2 (solution annealed) pipe and tube, SB-446 Grade 1 (annealed) and Grade 2 (solution annealed) rod and bar, and SB-564 may be used for welded construction in Section VIII, Division 2, Class 2, provided the following additional requirements are met:

(a) The allowable stress values, S, shall be those listed in Tables 1 and 1M. The maximum use temperature is 800°F (427°C) for both Grade 1 (annealed) and Grade 2 (solution annealed).

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

(1) The requirements of Section II, Part D, Figure NFN-17 shall be applied for Grade 1 (annealed) material.

(2) The requirements of Section II, Part D, Figure NFN-22 shall be applied for Grade 2 (solution annealed) material.

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

Table 1
Allowable Stress Values, *S*

For Metal Temperatures Not Exceeding °F	Allowable Stress Values for SB-443 Gr. 1 Annealed Material, ksi	Allowable Stress Values for SB-444 Gr. 1 Annealed Material, ksi	Allowable Stress Values for SB-446 Gr. 1 Annealed and SB-564 Material Up to 4 in. incl., ksi	Allowable Stress Values for SB-446 Gr. 1 Annealed and SB-564 Material Over 4 in. to 10 in. incl., ksi	Allowable Stress Values for SB-443 Gr. 2 Solution Annealed Material, ksi	Allowable Stress Values for SB-444 Gr. 2 Solution Annealed Material, ksi	Allowable Stress Values for SB-446 Gr. 2 Solution Annealed Material, ksi
100	36.7	40.0	40.0	33.3	26.7	26.7	26.7
200	35.3	38.5	38.5	32.1	24.6	24.6	24.6
300	34.3	37.4	37.4	31.2	23.4	23.4	23.4
400	33.3	36.3	36.3	30.3	22.5	22.5	22.5
500	32.4	35.3	35.3	29.4	21.7	21.7	21.7
600	31.5	34.4	34.4	28.6	21.0	21.0	21.0
650	31.1	33.9	33.9	28.3	20.8	20.8	20.8
700	30.7	33.5	33.5	27.9	20.5	20.5	20.5
750	30.4	33.2	33.2	27.6	20.3	20.3	20.3
800	30.1	32.9	32.9	27.4	20.1	20.1	20.1

GENERAL NOTE: Allowable stresses for Grade 2 materials are conservatively taken from Section II, Part D, Table 1B as specified for Section VIII, Division 1 use.

Table 1M
Allowable Stress Values, *S*

For Metal Temperatures Not Exceeding °C	Allowable Stress Values for SB-443 Gr. 1 Annealed Material, MPa	Allowable Stress Values for SB-444 Gr. 1 Annealed Material, MPa	Allowable Stress Values for SB-446 Gr. 1 Annealed and SB-564 Material Up to 100 mm incl., MPa	Allowable Stress Values for SB-446 Gr. 1 Annealed and SB-564 Material Over 100mm to 250mm incl., MPa	Allowable Stress Values for SB-443 Gr. 2 Solution Annealed Material, MPa	Allowable Stress Values for SB-444 Gr. 2 Solution Annealed Material, MPa	Allowable Stress Values for SB-446 Gr. 2 Solution Annealed Material, MPa
40	253	276	276	230	184	184	184
65	247	270	270	225	175	175	175
100	243	265	265	221	169	169	169
125	239	261	261	218	165	165	165
150	236	258	258	215	161	161	161
175	233	254	254	212	158	158	158
200	230	251	251	209	155	155	155
225	227	248	248	206	153	153	153
250	224	245	245	204	150	150	150
275	221	242	242	201	148	148	148
300	219	239	239	199	146	146	146
325	216	236	236	197	145	145	145
350	214	233	233	194	143	143	143
375	212	231	231	192	141	141	141
400	210	229	229	191	140	140	140
425	208	227	227	189	139	139	139
450 [Note (1)]	206	225	225	187	138	138	138

GENERAL NOTE: Allowable stresses for Grade 2 materials are conservatively taken from Section II, Part D, Table 1B as specified for Section VIII, Division 1 use.

NOTE: (1) This value is for interpolation purposes only. The maximum design temperature is 427°C.

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Case 2469-1
Pneumatic Testing

Section IV

Approval Date: October 21, 2009

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

Inquiry: Under what conditions may heating boilers manufactured and stamped in accordance with Section IV be tested pneumatically in lieu of the hydrostatic test required in HG-510(c)?

Reply: It is the opinion of the Committee that pneumatic testing may be substituted for the hydrostatic test required in HG-510(c), provided the following requirements are met:

(a) The water volume of the boiler shall be less than 70 gals (265 L).

(b) Maximum material thickness of any component part shall not exceed $\frac{1}{2}$ in. (12.7 mm). No components of the pressure vessel that will be subject to pneumatic testing may be constructed of cast iron.

(c) The MAWP shall not be greater than 160 psi (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.

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Case 2473-2
F-Number Grouping for Cr-Fe-Ni-Mo-Cu, Classification UNS R20033 Filler Metal

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

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.

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Case 2475
18Cr-9Ni-2.5W-V-Cb Austenitic Seamless Tube Steel

Section I

Approval Date: November 29, 2004

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

Inquiry: May solution-treated 18Cr-9Ni-2.5W-V-Cb austenitic stainless seamless tube steel with chemical analysis shown in Table 1, the mechanical properties shown in Table 2, and that otherwise conform to applicable requirements in specification SA-213 be used for steam service in Section I construction?

Reply: It is the opinion of the Committee that the material listed in the Inquiry may be used for steam service in Section I construction, provided the following requirements are met:

(a) The material shall meet the chemical analysis and minimum tensile requirements described in the Inquiry and shall otherwise meet the requirements of SA-213 as applicable, except as shown in paras. (b) and (c).

(b) The minimum solution treating temperature for this material shall be 2000°F (1100°C).

(c) This material shall have a hardness not exceeding 219 HB/230 HV (95 HRB).

(d) The rules of PG-19 for TP347H shall apply for this material, except that solution treatment, when required, shall be at the minimum temperature of 2000°F (1100°C).

(e) The maximum allowable stress values for the material shall be as given in Tables 3 and 3M. The maximum design temperature is 1427°F (775°C).

(f) Separate welding procedures and performance qualification shall be conducted for the material in accordance with Section IX.

(g) Welding processes shall be limited to GTAW and SMAW.

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

Table 1
Chemical Requirements

Element	Composition, %
Carbon, max.	0.05
Manganese, max.	2.00
Phosphorus, max.	0.040
Sulfur, max.	0.030
Silicon, max.	1.00
Nickel	8.00–11.0
Chromium	17.0–20.0
Columbium	0.25–0.50
Nitrogen	0.10–0.25
Tungsten	1.50–2.60
Vanadium	0.20–0.50

Table 2
Mechanical Property Requirements

Tensile strength, min. ksi (MPa)	90 (620)
Yield strength, min. ksi (MPa)	38 (260)
Elongation in 2 in. or 50 mm, min. %	30

Table 3
Maximum Allowable Stresses

For Metal Temperature Not Exceeding, °F	Allowable Stress Values, ksi	Allowable Stress Values, ksi
−20 to 100	25.3	25.3
200	20.0	24.9 [Note (1)]
300	17.9	23.5 [Note (1)]
400	16.6	22.4 [Note (1)]
500	15.7	21.1 [Note (1)]
600	15.0	20.2 [Note (1)]
650	14.7	19.8 [Note (1)]
700	14.4	19.4 [Note (1)]
750	14.1	19.1 [Note (1)]
800	13.9	18.7 [Note (1)]
850	13.7	18.5 [Note (1)]
900	13.5	18.2 [Note (1)]
950	13.3	18.0 [Note (1)]
1000	13.2	17.9 [Note (1)]
1050	13.2	17.8 [Note (1)]
1100	13.2	17.8 [Note (1)]
1150	13.2	15.6 [Note (1)]
1200	11.9	11.9
1250	9.1	9.1
1300	6.9	6.9
1350	5.3	5.3
1400	4.0	4.0
1450	3.1 [Note (2)]	3.1 [Note (2)]

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

NOTES:
(1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. These higher stress values exceed 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.

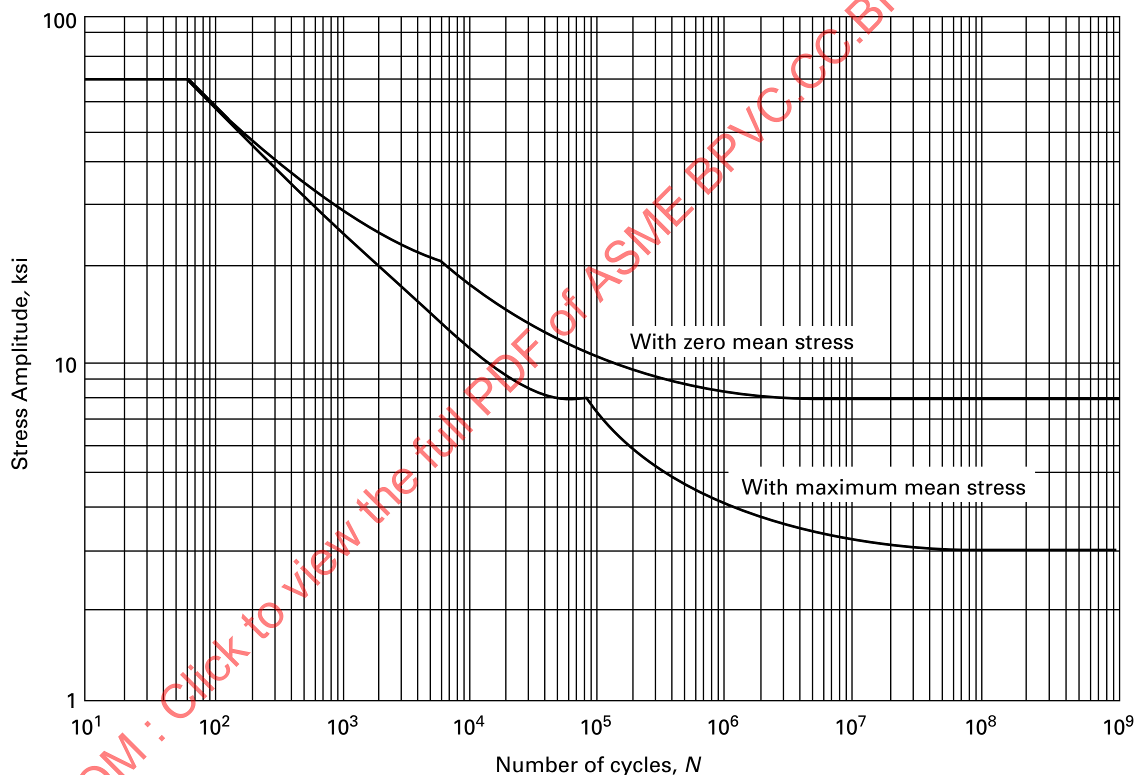
[1] This reinstated Case has been revised.

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

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Case 2481-1
Ni-29Cr-3.5Fe-3.3Al-1.5Nb Alloy (UNS N06693)

Section VIII, Division 1

Approval Date: November 17, 2016
Code Cases will remain available for use until annulled by the applicable Standards Committee.

Inquiry: May annealed austenitic Ni-29Cr-3.5Fe-3.3Al-1.5Nb Alloy (UNS N06693) wrought sheet, strip, plate, rod and bar, and seamless pipe and tubing with chemical analysis shown in Table 1 and minimum mechanical properties shown in Table 2 and otherwise conforming to one of the specifications shown in Table 3 be used in welded construction under the rules of Section VIII, Division 1?

Reply: It is the opinion of the Committee that material described in the Inquiry may be used in Section VIII, Division 1 construction at a design temperature of 1,200°F (649°C) or less, provided the following additional requirements are met:

(a) The maximum allowable stress values for material shall be those given in Tables 4 and 4M. The maximum design temperature shall be 1,200°F (649°C). For welded pipe and tube products, a joint efficiency factor of 0.85 shall be used.

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

(c) Heat treatment during or after fabrication is neither required nor prohibited. For Section VIII applications, all other requirements in Part UNF for nickel alloys shall be required.

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

Table 1
Chemical Composition

Element	Composition, %
Carbon, max.	0.15
Manganese, max.	1.0
Sulfur, max.	0.01
Silicon, max.	0.5
Nickel [Note (1)]	Balance
Chromium	27.0–31.0
Copper, max.	0.5
Iron	2.5–6.0
Aluminum	2.5–4.0
Titanium, max.	1.0
Niobium	0.5–2.5

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

Table 2
Mechanical Property Requirements (All Product Forms)

Tensile strength, min., ksi (MPa)	85 (586)
Yield Strength, min., ksi (MPa)	40 (276)
Elongation in 2 in., or 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.

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Case 2493-1
Parallel Plate Explosion Welding for Butt Joints Between Dissimilar Metals

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

Approval Date: September 12, 2017

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

Inquiry: May the Parallel Plate Explosion Welding Process (with or without interlayers) be used to weld dissimilar metal plate and sheet to produce butt joint transitions for cryogenic systems, which can then be welded by conventional processes to adjacent similar metals, be qualified under the rules of Section IX?

Reply: It is the opinion of the Committee that butt joints between dissimilar metal plate and sheet produced by Parallel Plate Explosion Welding (with or without interlayers) used to produce butt joint transitions for cryogenic systems may be qualified under the rules of Section IX, provided the joints meet the applicable requirements of Section IX, the specific ASME or other Design Code where they will be utilized, and the following requirements:

1 GENERAL REQUIREMENTS

(a) The welds shall be produced between parallel flat plates in the horizontal position in normal air atmosphere.

(b) The prime, interlayer, if used, and backer component materials shall meet the requirements of appropriate ASME SA- or SB- specifications. The backer component may consist of previous explosion welded plates for multilayer requirements.

(c) Where multilayer welded plates are produced, mechanical test specimens shall be taken from the finished multilayer welded plate with a single test representing all welds.

(d) Weld repairs to the explosion weld are prohibited. Weld repair of surface blemishes or defects that do not extend to nor affect the explosion weld is permissible. Procedures and welders shall be qualified in accordance with Section IX.

(e) Fabricators shall satisfy themselves through appropriate testing that subsequent heat treatment applied to completed weldments that include explosion welded 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		Division 2 Values, ksi	
	SA-789 Tube; Pipe, t < 0.40 in.	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	SA-789/SA-789M and ASTM A790/A790M for t < 0.40 in.	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		Division 2 Values, MPa	
	SA-789M Tube; Pipe, SA-789/SA-789M and ASTM A790/A790M for t < 10 mm	SA-789/SA-789M and ASTM A790/A790M for t ≥ 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 ≥ 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.