UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

5/9/83

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of

APPLICATION OF TEXAS UTILITIES GENERATING COMPANY, ET AL. FOR AN OPERATING LICENSE FOR COMANCHE PEAK STEAM ELECTRIC STATION UNITS #1 AND #2 (CPSES)

Docket Nos. 50-445 and 50-446

Docketed USNRC
MAY 12 1983
Office of the Sec. Docketing & Serv. Branch

CASE'S RESPONSE TO BOARD'S REQUEST FOR DISCUSSION OF INTERRELATIONSHIP OF ASME APPENDIX XVII, 2271.3, TO REST OF ASME CODE

By telephone request on May 6, 1983, the Board Chairman requested that the parties in this proceeding file a brief discussion of the interrelationship of ASME Appendix XVII, 2271.3, to the rest of the ASME Code. The Board Chairman requested that such discussions be in the hands of the Board and parties by Wednesday, May 11, 1983. CASE (Citizens Association for Sound Energy), Intervenor herein, hereby files this, its response to the Board's request.

XVII-2271.3 Provision for Expansion (CASE Exhibit 707) states:

"Adequate provision shall be made for expansion and contraction appropriate to the function of the support structure."

Article XVII 2000 is the portion of the ASME Code which provides the rules to be followed in linear elastic analysis (see CASE Exhibit 767 attached), and is referenced at ASME NF-3231.1[1] (CASE Exhibit 744, page 37, attached to CASE's 4/20/83 Brief on LOCA) linear type supports analysis procedure.

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[1] The statement in NF-3231.1(a) "shall be limited to three times the stress limits of XVII-2000" is a contradiction of terms. The provisions of XVII-2000 include the rules for linear elastic analysis, which by definition limits the allowable stresses to a maximum of about 1.2 F_y (at temperature) considering the shape factors involved. (CASE Exhibit 767, page 365, XVII-1121 Linear Elastic Analysis). To exceed this limit is to venture far into the realm of plastic design which is unpredictable for three-dimensional space frames with compression members that are bending bi-axially. (See CASE Exhibit 770, STEEL STRUCTURES Design and Behavior, Salmon and Johnson.) The statement in NF-3226.4 (CASE Exhibit 744, page 36) is not referring to stresses in the 2 F_y range. (continued)

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Beyond this, inclusion of XVII is mandatory, per ASME Section III, Subsection NCA Organization of Section III (D) References to Appendices. (See CASE Exhibit 769.) Appendices marked with Roman numerals are mandatory; for example, XVIII. Appendices marked by capital letters are non-mandatory; for example, Appendix "F".

XVII-2271.3 Provision for Expansion (CASE Exhibit 707), requires including consideration due to expansion of the structure; for example, if friction joints[2] are designed to a predictable level and such effects are incorporated into the analysis of the structure, the provisions are being complied with as far as the requirements of Section XVII of the Code.

Such joints under LOCA conditions, regardless of the temperature levels, within reason will be accommodated by joint slip once the load: cause displacements at the joints to exceed the predictable design load of the joint (friction values).

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1 (continued) The concept of "three times the stress limits" is possibly derived from the pipe stress rules which include "3 S_m."

The term S_m is used frequently in the contents of ASME Appendix F and Subsection NF; see: NF-3222.3, Expansion Stress Intensity; NF-3226.1 Bearing Loads; NF-3226.2, Pure Shear; at NF-3229, Design Stress Values, locates the source of S_m as being Table I-1.1 and I-11.1. (See CASE Exhibits 746 and 744, respectively.) But structural tube is not defined in these tables, but rather in Code Case N71-10. (See CASE Exhibits 751 and 754, attached.) The use of S_m is also generously distributed throughout Appendix F. For example, at F-1323.3 Elastic System Analysis and Component Stress Ratio Analysis (b) allows stress levels to 3.0 S_m or 0.7 S_u. Whenever S_m is factored up the caveat not to exceed 0.7 S_u is used in Appendix F; see Table F-1322.2-1. In any event, S_m is for materials other than structural tubes which are covered by N71-10.

S_m is based on about .4 S_y and is therefore not the same ratio as is used in structures. For example, 3 S_m equals 1.2 S_y but 3 F_b equals 1.8 to 2.0 S_y. In the case of the former, the analysis is still elastic but the same is not true of the latter.

Beyond this, three times the allowable of Appendix XVII would be a higher allowable than Appendix F-1370 allows (normal load allowable times 1.2 (S_u/Ft)), which is not rational.

2 As discussed on page 7 of this pleading.

The current design of bearing joints[3], while it may be acceptable in some cases for LOCA expansion[4], must under seismic conditions now be considered as pin joints (at best) and the current pipe support analysis is therefore less than accurate.

The confusion in this issue involves the use of the "buzz" words "thermal stresses." Each of the Applicants' expert witnesses has made the same fundamental error -- equating the effects of expansion stress to thermal stress: Mr. Finneran (see Applicants' Exhibit 142, page 1, Answer No. 1); Mr. Krishnan (see Applicants' Exhibit 142, pages 11 and 12, Answer No. 30); Dr. Chang (see Applicants' Exhibit 142, page 12, Answer 31); Mr. Reedy (see Applicants' Exhibit 142, page 14, Answers 38 and 39, and tr. 5218/10-22, 5215/15-25, 5216/1-25); and Mr. Scheppele (see Applicants' Exhibit 142, page 22, Answer No. 57). Beyond this, the same error was repeated by Mr. Tapia of the NRC Staff (see Staff Rebuttal Testimony, September hearings, Staff Exhibit 201, pages 4, 5 and 6, Answers 8 and 9, and tr. 5375/1-8, 5376/1-10), and this error is now repeated as if it were established fact due to repetition.

The Applicants have equated constraint of free-end displacement with thermal stresses. This is a gross error. (See CASE Exhibits 669B: 9CC, "Section B, Temperature Stresses, Strength of Materials, Fitzgerald;" 9DD, "Thermal and Prestrain 1.7 Mechanics of Materials, Timoshenko;" 9X, "at 8.9 Effects of Temperature Change and Support Settlement. Theory of Structures, Timoshenko and Young, McGraw Hill;" 9F, "Table 17.4 Expansion and Contraction of Structures, Bridge Engineering from Standard Handbook for Civil Engineers, Merrit.")

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[3] As discussed on page 6 of this pleading.

[4] Resulting from environmental condition following LOCA.

The interpretation of thermal stress which appears in the Applicants' 5/3/83 Reply Brief, as shown below, causes no problem to CASE; it is the erroneous interpretation of where these characteristics apply and the use of this phrase in negating Code requirements with which we are concerned.

The following interpretations appear on pages 4 and 9, respectively, of Applicants' 5/3/83 Reply Brief Regarding Consideration of LOCA in Design Criteria for Pipe Supports:

Page 4 Thermal Stresses:

"NB-3213.13 Thermal Stress is a self-balancing stress produced by a non-uniform distribution of temperature or by differing thermal coefficients of expansion. Thermal stress is developed in a solid body whenever a volume of material is prevented from assuming the size and shape that it normally should under a change in temperature." (Emphasis added by Applicants.)

Page 9 (New Addenda[5]):

"NF-3121.11 Thermal Stress - Thermal stress is a self-equilibrating stress produced by a non-uniform distribution of temperature or by differing thermal coefficients of expansion. Thermal stress is developed in a solid body whenever a volume of material is prevented from assuming the size and shape it normally would under a change in temperature. Evaluation of thermal stresses in the support is not required by this Subsection." (Emphasis added by the Applicants.)

The key phrase in the body of ASME in relation to thermal stresses is "self-relieving," not exterior relief. In all cases of structural analysis involving structures subjected to temperature changes, the element (post, bolt, etc.) that results in the relief is doing so without necessarily experiencing thermal stress; for example, a frame consisting of two columns and a beam (a simple bent) when subjected to elevated temperatures will expand. The two columns which are free to expand will have no thermal stresses. However, the columns do restrain the growth of the beam. The question is: if the growth of the cross beam

[5] From ASME Winter 1982 Addenda, December 31, 1982.

is of sufficient magnitude to overstress the beam or fail the joint, did these failures result from thermal stresses or stresses induced by exterior loads (displacement of the members)? The answer is obvious: due to a lack of thermal stress, the problem is primary stresses. See CASE Exhibit 768, Winter 1982 Addenda, December 31, 1982, ASME Subsection NF-3121.2 Primary Stress, last sentence, which states:

> "In addition to the above, for piping and component supports, stresses induced in the support by restraint of free end displacement (NF-3111(e) and (f)) and anchor motion of piping are considered primary stresses." (Emphases added.)

Compare the above to the statements made by the Applicants that the expansion load is not an external load (Mr. Scheppele, tr. 5121/4-10; Mr. Reedy, tr. 5203/23-25). But the results of thermal expansion are that it exerts an external load on the reacting members.

There are many points in the testimony of the Applicants that are inaccurate, to say the least. Mr. Reedy, in Applicants' Exhibit 142, page 15, Answer 40, states that the general requirements of NF-3100 merely identify loads that should (this word conveys the idea of suggestion) be included (emphasis added). From this point, Mr. Reedy goes through an exercise to explain that specific rules depend on class, type and loading condition but ultimately winds up declaring that the Code does not require the consideration of thermal conditions, citing NF-3231. To quote from the pertinent section of Sub-Section NF-3111 (CASE Exhibit 659B, Attachment to Mark Walsh Testimony):

> "NF-3111 Loading Conditions
>
> "The loadings as specified in the Design Specifications (NA-3250) that shall be taken into account in designing a component support include, but are not limited to, the following:
>
> ". . . (e) Restrained thermal expansion;
> ". . . (g) Environmental loads . . ." (Emphases added.)

The word "shall" is not a suggestion but indicates that the requirement is mandatory. Therefore, not only are the environmental conditions a required part of the design specifications but also any other engineering fundamental, which if not included could result in a deficiency to safe operation of the plant. This is also mandated by the phrase overlooked by Mr. Reedy "but not limited to." (Emphasis added.)

We are not concerned with thermal stresses but are in fact concerned with the effects of "constraint of free end displacement" or the expansion of elements of the support. The affected members which we are addressing do not necessarily exhibit any thermal differential but are being displaced by another member which is reacting thermally.

At this point, it may be helpful to briefly discuss bearing type connections as opposed to friction type connections, to help clarify what is currently being done at Comanche Peak and its relationship to the question posed regarding the interrelationship of ASME XVII-2271.3 to the rest of the ASME Code.

The current design practice for NPSI supports is to use bearing joints, without slotted connections. This does not allow the members to expand and contract freely. A bearing joint as designed at CPSES behaves as the name implies: the supported member bears against the bolt, and in turn the bolt does not allow the member to expand or contract with predictability. If the joint were to be designed with slotted connections, and installed with slotted connections, the supported member would be able to move in the direction of the slot, but would be restrained

in the other two directions. The bearing type connection has disadvantages in a nuclear power plant (see discussion, first paragraph, page 3, of this pleading).

As already stated above, the bolt provides restraint against expansion of the supported member. In addition to this problem, the bolt may not be bearing against the supported member due to the bolt hole's being larger than the bolt but not necessarily an exact snug fit. This condition would invalidate the assumption made by the engineers that the connection is rigid and does not slip or move in a seismic event. Consequently, the use of bearing-type connections cannot provide assurance for bearing under seismic conditions, or allow expansion of supported members at elevated temperatures.

To alleviate the problems of bearing type connections, friction type connections are commonly used in structures except for NPSI supports in general. A friction type of connection works as the name implies; i.e., on friction. A bolt is put in tension either by pulling on it with a hydraulic ram or by using a torque wrench. When the bolt has achieved the specified tension, the connected parts are pressed against one another and pretensioned.

Now to move the supported member, the required force would be equal to the pretension force that pressed it together times a coefficient of friction. When using this type of connection, oversized holes will not impair the seismic design, if the pretension force is greater than the design load. And for the restraint of the connection for expansion, the result using a slotted connection would be as follows: The member will

try to expand but will be restrained up to the prestressed force of the bolt times the coefficient of friction. When the member reaches this value the plane of friction will break and allow the member to move; thus the maximum force in the restrained member will not exceed the predicted value of the friction plane.

To accommodate the friction type connection, high strength bolts are commonly used; for example, A325 bolts and A490 bolts. The yield strength for this bolt material starts at a minimum of 80 ksi. (It should be noted that the yield strength for the threaded rod used at Comanche Peak is 36 ksi.) This high value of 80 ksi is required so as to achieve the high pretension force in the bolt, which in turn is required to avoid slippage.

The friction type of connection has one drawback, that is unique to Comanche Peak. This is the current NPSI design which has the bolt passing through the tube steel. When the pretension force is applied to the bolt, the webs of the tube steel will not be able to withstand the large force and consequently will collapse. To alleviate this problem, a method of using base plates could be used, and is generally used throughout the industry.

The common NPSI support configuration is a simple or continuous span support with the reaction points being the Richmond insert connections and the beam being the tube steel. Paragraph XVII-2271.2 addresses design considerations for continuous span supports, and is stated as follows:

> "XVII-2271.2 Continuous Spans. When designed on the assumption of full or partial end restraint, due to continuous, semi-continuous, or cantilever action, the beams, girders, and trusses, as well as the sections of the members to which they connect, shall be designed to carry the shears and moments so introduced, as well as all other forces, without exceeding at any point the unit stresses prescribed in SVII-2110, except that some nonelastic but self-limiting deformation of a part of the connection may be permitted when this is essential to the avoidance of overstressing of fasteners."

The phrase "but self-limiting deformation" applies tc the material configuration. For the stresses to be self-limiting requires the material to be ductile as well as the ability of the material to change its original configuration to accommodate the bearing stresses, but not its basic material properties.

With a slight load, the bolt and bolt hole are in pinpoint contact, and the resulting stress would be quite high. But when larger loads are applied, the bolt hole will deform very slightly and will decrease the bearing stresses. The stresses induced for the connected member by the larger loads are bearing stresses where the bolt hole comes in contact with the bolt, and do not include shear stress in the bolt, tension in the bolt due to prying, or other external tension loads.

The nonelastic but self-limiting deformation is addressed in the design for bearing stresses. The allowable stress in bearing is defined in XVII-2216.1 as $F_p = .9S_y$. The bearing area is calculated as the thickness of the material times the nominal bolt diameter. As shown above, the total bolt is not in contact for its full diameter; consequently, for the bearing stress to become effective, some slight deformation will occur so that the net effect due to bearing will accommodate the nominal bolt diameter.

The allowable bearing stress is based on an elastic analysis, and not on a plastic (non-elastic) analysis. If a plastic analysis is performed for the structure or connected parts, then the above allowable is not valid, since the allowables above are based on elastic behavior.

In conclusion, as demonstrated herein, Appendix XVII and specifically XVII-2271.3 is a mandatory and integral part of the ASME Code. Further, it is applicable to Comanche Peak specifically, including the pipe supports at Comanche Peak. Applicants should be required to consider it accordingly.

Respectfully submitted,

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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CERTIFICATE OF SERVICE

By my signature below, I hereby certify that true and correct copies of

CASE's Response to Board's Request for Discussion of Interrelationship of

ASME Appendix XVII, 2271.3, to Rest of ASME Code

have been sent to the names listed below this 9th day of May, 1983, by: Express Mail where indicated by * and First Class Mail elsewhere.

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CASE EXHIBIT 751

SUPPLEMENT NO. 14

CODE CASES

1980 EDITION

Nuclear Components

The new and revised Cases which appear in
this Supplement were considered at the Boiler and
Pressure Vessel Committee meeting
dates shown on the Cases and approved by Council
on the dates shown on the Cases.

Business & Technology

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CASE EXHIBIT 754

Revision 20
November 1982

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.85

MATERIALS CODE CASE ACCEPTABILITY ASME SECTION III DIVISION 1

A. INTRODUCTION

Section 50.55a, "Codes and Standards," of 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires, in part, that components of the reactor coolant pressure boundary be designed, fabricated, erected, and tested in accordance with the requirements for Class 1 components of Section III, "Nuclear Power Plant Components,"[1] of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code or equivalent quality standards. Footnote 6 to §50.55a states that the use of specific Code Cases may be authorized by the Commission upon request pursuant to §50.55a(a)(2)(ii), which requires that proposed alternatives to the described requirements or portions thereof provide an acceptable level of quality and safety.

General Design Criterion 1, "Quality Standards and Records," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 requires, in part, that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed. Where generally recognized codes and standards are used, Criterion 1 requires that they be identified and evaluated to determine their applicability, adequacy, and sufficiency and be supplemented or modified as necessary to ensure a quality product in keeping with the required safety function.

Criterion 30, "Quality of Reactor Coolant Pressure Boundary," of the same appendix requires, in part, that components that are part of the reactor coolant pressure boundary be designed, fabricated, erected, and tested to the highest quality standards practical.

Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 requires, in part, that measures be established for the control of special processing of materials and that proper testing be performed.

This regulatory guide lists those Section III ASME Code Cases oriented to materials and testing that are generally acceptable to the NRC staff for implementation in the licensing of light-water-cooled nuclear power plants.

B. DISCUSSION

The Boiler and Pressure Vessel Committee of the ASME publishes a document entitled "Code Cases."[1] Generally, the individual Code Cases that make up this document explain the intent of Code rules or provide for alternative requirements under special circumstances.

Most Code Cases are eventually superseded by revision to the Code and then are annulled by action of the ASME Council. In such cases, the intent of the annulled Code Case becomes part of the revised Code, and therefore continued use of the Code Case intent is sanctioned under the rules of the Code. In other cases, the Code Case is annulled because it is no longer acceptable or there is no further requirement for it. A Code Case that was approved for a particular situation and not for a generic application should be used only for construction of the approved situation because annulment of such a Code Case could result in construction that would not meet Code requirements.

The Code Cases listed in this guide are limited to those cases applicable to Section III that are oriented toward materials and testing.

All published Code Cases in the area of materials and testing that are applicable to Section III of the Code and were in effect on April 2, 1982, were reviewed for inclusion in this guide.[e] In addition to the listing of acceptable Code Cases, this revision of the guide includes listings of

[1]Copies may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, New York 10017.

[e]Lines indicate substantive changes from Revision 19.

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these [illegible]

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

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(1) Code Cases that were identified as acceptable in a prior version of this regulatory guide and that were annulled after the original issuance of this guide (June 1974) and (2) Code Cases that were identified as acceptable in a prior version of this regulatory guide and that were superseded by revised Code Cases after the original issuance of this guide (June 1974). Code Cases that are not listed herein are either not endorsed or will require supplementary provisions on an individual basis to attain endorsement status.

The endorsement of a Code Case by this guide constitutes acceptance of its technical position for applications not precluded by regulatory or other requirements or by the recommendations in this or other regulatory guides. Contingent endorsement is indicated in regulatory position C.1.a for specific cases. However, it is the responsibility of the user to make certain that no regulatory requirements are violated and that there are no conflicts with other recommended limitations resulting from Code Case usage.

Acceptance or endorsement by the NRC staff applies only to those Code Cases or Code Case revisions with the date of "Council Approval" as shown in the regulatory position of this guide. Earlier or later revisions of a Code Case are not endorsed by this guide. New Code Cases will require evaluation by the NRC staff to determine if they qualify for inclusion in the approved list. Because of the continuing change in the status of Code Cases, it is planned that this guide will require periodic updating to accommodate new Code Cases and any revisions of existing Code Cases.

C. REGULATORY POSITION

1. The Section III ASME Code Cases[2] listed below (by number, date of Council approval, and title) are acceptable to the NRC staff for application in the construction of components for light-water-cooled nuclear power plants. Their use is acceptable within the limitations stated in the "Inquiry" and "Reply" sections of each individual Code Case, within the limitations of such NRC or other requirements as may exist, and within the additional limitations recommended by the NRC staff given with the listing. The categorization of individual Code Cases in the listing. The categorization of Code Cases used in this guide is intended to facilitate the Code Case listing and is not intended to indicate a limitation on its usage.

a. Materials-oriented Code Cases (Code Case number, date of Council approval,[3] and title):

(1) Code Cases involving plate:

1358-5 (N-7)	11-03-75 01-08-79 01-21-82	High Yield Strength Steel, Section III, Division 1, Class 1 Vessels

Code Case 1358-5 is acceptable subject to the following condition in addition to those conditions specified in the Code Case: The information required to be developed by Note 1 in the Code Case should be provided in each referencing Safety Analysis Report.

1571 (N-41)	03-03-73 01-08-79 01-21-82	Additional Material for SA-234 Carbon Steel Fittings, Section III

(2) Code Cases involving pipe and tubes:

1474-1 (N-17)	10-29-71 01-08-79 01-21-82	Integrally Finned Tubes for Section III
1484-3 (N-20)	08-13-76 08-30-79	SB-163 Nickel-Chromium-Iron Tubing (Alloy 600 and 690) and Nickel-Iron-Chromium Alloy 800 at a Specified Minimum Yield Strength of 40.0 Ksi Section III, Division 1, Class 1
1527 (N-26)	06-26-72[4] 01-08-79 01-21-82	Integrally Finned Tubes, Section III
1794 (N-157)	01-14-77 01-07-80	Use of Seamless Al-Br, Alloy CDA 614 Pipe, Section III, Division 1, Class 3
N-188-1	05-15-78 07-13-81	Use of Welded Ni-Fe-Cr-Mo-Cu (Alloy 825) and Ni-Cr-Mo-Cb (Alloy 625) Tubing, Section III, Division 1, Class 2 and 3
N-224-1	05-11-81	Use of ASTM A500 Grade B and ASTM A501 Structural Tubing for Welded Attachments for Section III, Class 2, 3, and MC
N-294	08-25-80	SB-148 Alloy 952 and 954, and SB-62 Alloy 836 Fittings, Section III, Division 1, Class 2
N-321	07-13-81	Use of Modified SA-249, Type 304 for Section III, Division 1, Class 1 Construction
N-342	04-02-82	Use of SA-249 and SA-312 Type 317 Stainless Steel, Section III, Division 1, Class 1, 2, and 3

(3) Code Cases involving bars and forgings:

1335-10 (N-3-10)	08-28-78 08-28-81	Requirements for Bolting Materials, Section III
1337-11 (N-4-11)	05-15-78 07-13-81	Special Type 403 Modified Forgings or Bars, Section III, Division 1, Class 1 and CS
1542-1 (N-33)	04-29-74 01-08-79 01-21-82	Type 403 Forgings or Bars for Bolting Material, Section III
1626-1 (N-65-1)	01-08-79 01-21-82	Normalized and Tempered 1-1/4 Cr Low Alloy Steel Forgings, Section I and Section III

[2]A numerical listing of the Code Cases appears in the appendix.

[3]When more than one date is given, the earlier date is that on which the Code Case was approved by the ASME Council and the later date(s) is that on which the Code Case was reaffirmed by the ASME Council.

[4]Corrected date.

1747 (N-124)	03-01-76 01-08-79 07-13-81	Requirements for Martensitic Stainless Steel Forgings with 13% Chromium and 4% Nickel, Section III, Division 1
1772 (N-140)	08-13-76 08-30-79	Use of SA-453 Bolts in Service Below 800°F Without Stress Rupture Tests, Section III, Division 1
1793 (N-156)	01-14-77 01-07-80	Structural Steel Rolled Shapes, Section III, Division 1, Class 2, 3, and MC
N-259	01-07-80	Ni-Cu-Al Bolting Material SB 164 Modified, Section III, Division 1, Class 3
N-299	11-17-80	Use of Nickel-Chromium-Molybdenum-Columbium Alloy 625 Forgings, Section III, Division 1, Class 2 and Class 3 Components
N-310-1	08-14-81	Certification of Bolting Materials, Section III, Division 1, Class 1, 2, 3, MC, and CS

Code Case N-310-1 is acceptable subject to the following conditions in addition to those conditions specified in the Code Case: Each applicant who applies the Code Case should indicate in the referencing Safety Analysis Report (1) in what way the bolting does not meet NCA-3800 (or NA-3700), (2) where the bolting will be used in the plant, and (3) how it will be shown that the bolting material properties required by the Equipment Support Design Specification are present in the actual bolting material.

(4) Code Cases involving general usage:

1344-5 (N-5)	04-29-74 01-08-79 01-21-82	Nickel-Chromium, Age-Hardenable Alloys, (Alloy X750) Section III
1618-2 (N-60)	03-01-76 01-08-79 01-21-82	Material for Core Support Structures – Section III, Division 1, Subsection NG

Code Case 1618-2 is acceptable subject to the following condition in addition to those conditions specified in the Code Case: Welding of age-hardenable alloy SA-453 Grade 660 and SA-637 Grade 688 should be performed when the material is in the solution-treated condition.

N-71-10	05-11-81	Additional Materials for Component Supports Fabricated by Welding, Section III, Division 1, Subsection NF, Class 1, 2, 3, and MC Component Supports

Code Case N-71-10 is acceptable subject to the following condition in addition to those conditions specified in the Code Case: The maximum measured ultimate tensile strength (UTS) of the component support material should not exceed 170 Ksi in view of the susceptibility of high-strength materials to brittleness and stress corrosion cracking. Certain applications may exist where a UTS value of up to 190 Ksi could be considered acceptable for a material and, under this condition, the Design Specification should specify impact testing for the material. For these cases, it should be demonstrated by the applicant that (1) the impact test results for the material meet code requirements and (2) the material is not subject to stress corrosion cracking by virtue of the fact that (a) a corrosive environment is not present and (b) the component that contains the material has essentially no residual stresses or assembly stresses, and it does not experience frequent sustained loads in service. In the last sentence of paragraph 5.3, reference should be made to paragraph 4.5.2.2, "Alternate Atmosphere Exposure Time Periods Established by Test," of the AWS D.1.1 Code for the evidence presented to and accepted by the Authorized Inspector concerning exposure of electrodes for longer periods of time.

1714-2 (N-102-2)	08-28-78 07-13-81	Postweld Heat Treatment of P-1 Material, Section III, Class MC
1754 (N-126)	01-14-77 01-07-80	Hard Surfacing by the Spray-Fuse Method, Section III, Class 1, 2 and 3 Construction
1759-1 (N-131-1)	05-15-78 07-13-81 12-11-81	Material for Internal Pressure Retaining Items for Pressure Relief Valves, Section III, Division 1, Class 1, 2, and 3

Code Case 1759-1 is acceptable subject to the following condition in addition to those conditions specified in the Code Case: Applicants using this Case should also use Code Case 1711 for the design of pressure relief valves.

1782 (N-148)	09-10-76 08-30-79	Use of Copper-Nickel Alloy 962 for Castings, Section III, Division 1, Class 3 Construction
N-205	05-15-78 07-13-81	Use of Ductile Iron SA-395 for Section III, Division 1, Class 3 Construction
N-206	03-20-78 03-16-81	Use of ASTM B151-75 Copper-Nickel Alloy 706 Rod and Bar for Section III, Division 1, Class 3 Construction
N-207-1	03-19-79 01-21-82	Use of Modified SA-479 Type XM-19 for Section III, Division 1, Class 1, 2, 3, or CS Construction
N-242-1	04-10-80	Materials Certification, Section III, Division 1, Classes 1, 2, 3, MC, and CS Construction

Code Case N-242-1 is acceptable subject to the following condition in addition to those conditions specified in the Code Case: Applicants should identify in their Safety Analysis Reports the components and supports for which the Code Case is being applied and should specify the respective paragraphs of the Code Case.

N-245	07-09-79	Use of ASTM B61-76 and B62-76 Copper Alloy Castings for Section III, Division 1, Class 3 Construction
N-246	[illegible]-09-79	Use of SB-169, Alloy CA 614, Section III, Division 1, Class 3

N-249-1	05-11-81	Additional Materials for Component Supports Fabricated Without Welding, Section III, Division 1, Subsection NF, Class 1, 2, 3 and MC Component Supports

Code Case N-249-1 is acceptable subject to the following condition in addition to those conditions specified in the Code Case: Paragraph 7 of the "Reply" should reference the requirements of NF-2600 instead of NF-2800. This is a typographical error in that NF-2800 does not exist.

N-265	01-07-80	Modified SA-487 Castings, Section III, Division 1, Class 1
N-295	01-15-81 12-11-81	NCA-1140, Materials, Section III, Division 1
N-296	11-17-80	Welding Material, Section III, Division 1 Construction
N-337	04-02-82	Use of ASTM B525-70 Grade II, Type II, Sintered Austenitic Stainless Steel for Class 2, 3, and MC Component Standard Supports, Section III, Division 1

b. Testing-oriented Code Cases:

(1) Code Cases involving plates:

1407-3 (N-10)	07-01-74 01-08-79 01-21-82	Time of Examination for Classes 1, 2, and 3 Section III Vessels
N-227	07-09-79	Examination of Repair Welds, Section III, Class 2 and 3 Tanks

(2) Code Case involving bars and forgings:

N-329	12-11-81	Examination of Bar Material, Section III, Division 1, Class 1

(3) Code Case involving pipe and tubes:

1755-1 (N-127)	01-14-77 01-07-80	Alternative Rules for Examination of Welds in Piping, Section III, Class 1 and 2 Construction

(4) Code Cases involving general usage:

1820 (N-177)	03-23-77 03-17-80	Alternative Ultrasonic Examination Technique, Section III, Division 1
N-274	03-17-80	Alternative Rules for Examination of Weld Repairs for Section III, Division 1 Construction

Code Case N-274 is acceptable subject to the following condition[5] in addition to those conditions specified in the Code Case. Paragraph 6 should be expanded as follows: The ultrasonic examination procedures shall be proven by actual demonstration, to the satisfaction of the Authorized Nuclear Inspector, that the procedures are capable of detecting unacceptable cracks according to Section XI requirements.

N-298	11-17-80	Examination of Component Supports, Section III, Division 1, Class 1, 2, 3, and MC

2. Code Cases that were endorsed by the NRC in a prior version of this guide and were later annulled by action of the ASME Council should be considered as deleted from the list of acceptable Code Cases as of the date of the ASME Council action that approved the annulment. Such Code Cases that were annulled on or after July 1, 1974, are listed in the following by number, effective dates,[6] and title.[7]

1141-1	08-31-61 07-23-76	Foreign Produced Steel
1332-7 (N-1-7)	01-08-79 07-01-82	Requirements for Steel Forgings, Section III, Division 1
1334-3 (N-2)	04-29-74 01-08-79 01-01-81	Requirements for Corrosion-Resisting Steel Bars and Shapes, Section III
1345-2 (N-6)	03-09-72 03-01-79	Requirements for Nickel-Molybdenum-Chromium-Iron Alloys, Section III
1395-4 (N-9-4)	01-08-79 07-01-82	SA-508, Class 2 Forgings with Modified Manganese Content, Section III
1412-4	11-03-75 01-01-77	Modified High Yield Strength Steel for Section III, Division 1, Class 1 Vessels

Code Case 1412-4 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: The information required to be developed by Note 1 in the Code Case should be provided in each referencing Safety Analysis Report. The material given in the Inquiry section of the Code Case should be SA-508, Class 4b, instead of SA-508, Class 4.

1414-5 (N-11-5)	08-29-77 08-29-80	High Yield Strength Cr-Mo Steel for Section III, Division 1, Class 1 Vessels

Code Case 1414-5 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: The information required to be developed by Note 1 in the Code Case should be provided in each referencing Safety Analysis Report.

1423-2	03-09-72 07-01-77	Wrought Type 304 and 316 with Nitrogen Added, Sections I, III, VIII, Division 1 and 2

[5]The reason for the conditional acceptance of paragraph 6 is to make certain that there is a qualified ultrasonic testing procedure capable of detecting small flaws and differentiating the small flaws from geometric reflectors. This paragraph does not in any way alter the acceptance criteria as specified in paragraph 3.

[6]Earlier date–date Code Case was approved by ASME Council; later date–date Code Case was annulled. Where more than two dates appear, the last date is the date that the Code Case was annulled. The middle date (or dates) was the date of reaffirmation of the Code Case.

[7]Code Cases 1401-1, 1493-1, and 1599, which were listed in the original issue of this guide, were annulled by Council action prior to July 1, 1974.

N-223	11-30-78 11-20-81	Requirements for Stainless Steel Precipitation Hardening, Section III, Division 1, Class MC
N-225	11-20-78 01-01-81	Certification and Identification of Material for Component Supports, Section III, Division 1
N-248	08-30-79 07-01-80	Alternative Reference Radiographs, Section III, Division 1, Classes 1, 2, 3, MC, and CS Construction
N-267	01-07-80 07-01-81	Double-Wall Radiography, Section III, Division 1, Class 1 and 2
N-277	03-17-80 09-17-80	Use of Type XM-19 Austenitic Stainless Steel for Section III, Division 1, Class MC Construction
N-317	07-13-81 07-01-82	ASTM A276 Bar Section III, Division 1

3. Code Cases that were endorsed by the NRC in a prior version of this guide and were superseded by revised Code Cases on or after July 1, 1974, should be considered as not endorsed as of the date of the Council action that approved the revised version of the Code Cases. These Code Cases that are no longer endorsed are listed in the following by number, effective dates,[12] and title.[13]

1332-6	03-09-72 01-08-79	Requirements for Steel Forgings, Section III and VIII, Division 2
1335-9	04-29-74 08-28-78	Requirements for Bolting Materials
1337-9	04-29-74 04-28-75	Special Type 403 Modified Forgings or Bars, Section III
1337-10	04-28-75 05-15-78	Special Type 403 Modified Forgings or Bars, Section III
1395-3	11-06-72 01-08-79	SA-508, Class 2 Forgings with Modified Manganese Content, Section III or Section VIII, Division 2
1407-2	06-26-72 07-01-74	Time of Examination for Class 1, 2, and 3, Section III Vessels
1414-3	11-03-75 03-01-76	High Yield Strength Cr-Mo Steel for Section III, Division 1, Class 1 Vessels

Code Case 1414-3 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: The information required to be developed by Note 1 in the Code Case should be provided in each referencing Safety Analysis Report.

1414-4	03-01-76 08-09-77	High Yield Strength Cr-Mo Steel for Section III, Division 1, Class 1 Vessels

Code Case 1414-4 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: The information required to be developed by Note 1 in the Code Case should be provided in each referencing Safety Analysis Report.

1484-1	04-29-74 11-04-74	SB-163 Nickel-Chromium-Iron Tubing (Alloy 600) at a Specified Minimum Yield Strength of 40.0 Ksi, Section III, Class 1
1484-2	11-04-74 08-13-76	SB-163 Nickel-Chromium-Iron Tubing (Alloy 600 and 690) at a Specified Minimum Yield Strength of 40.0 Ksi, Section III, Class 1
1492[14]	10-29-71 03-03-75	Post Weld Heat Treatment, Section I, III and VIII, Division 1 and 2
1557-2	12-17-73 01-08-79	Steel Products Refined by Secondary Remelting
1618	03-02-74 03-03-75	Material for Core Support Structures – Section III, Subsection NG

Code Case 1618 was acceptable subject to the following conditions in addition to those specified in the Code Case:

a. Welding of age-hardenable alloy SA-453 Grade 660 and SA-637 Grade 688 should be performed when the material is in the solution-treated condition.

b. Use of alloy ASTM A-564 Grade 631 is not acceptable on a generic basis.

1618-1	03-03-75 03-01-76	Material for Core Support Structures Section III, Subsection NG

Code Case 1618-1 was acceptable subject to the following condition in addition to those specified in the Code Case: Welding of age-hardenable alloy SA-453 Grade 660 and SA-637 Grade 688 should be performed when the material is in the solution-treated condition.

1626	03-02-74 01-08-79	Normalized and Tempered 1-1/4 Cr Low Alloy Steel Forgings, Section 1, Section III, and Section VIII, Division 1 and 2
1634	07-01-74 08-12-74	Use of SB-359 for Section III, Class 3 Construction
1634-1	08-12-74 08-13-76	Use of SB-359 for Section III, Class 3 Construction
1644	08-12-74 04-28-75	Additional Materials for Component Supports – Section III, Subsection NF, Class 1, 2, 3, and MC Construction

Code Case 1644 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: The maximum measured ultimate tensile strength of the component support material should not exceed 170 Ksi.

1644-1	04-28-75 06-30-75	Additional Materials for Component Support – Section III, Subsection

[12] Earlier date–date Code Case was approved by ASME Council; later date–date revision of Code Case was approved by ASME Council.

[13] Code Cases 1334-2, 1337-7, 1344-3, 1484, 1521, and 1542, which were listed in the original issue of this guide, were revised by the ASME prior to July 1, 1974.

[14] Code Case 1492 is no longer listed by ASME as a Section III Code Case and is therefore deleted from the acceptable listing.

NF, Class 1, 2, 3, and MC Construction

Code Case 1644-1 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: The maximum measured ultimate tensile strength of the component support material should not exceed 170 Ksi.

1644-2	06-30-75 11-03-75	Additional Materials for Component Supports – Section III, Subsection NF, Class 1, 2, 3 and MC Construction

Code Case 1644-2 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: The maximum measured ultimate tensile strength of the component support material should not exceed 170 Ksi.

1644-3	11-03-75 03-01-76	Additional Materials for Component Supports – Section III, Subsection NF, Class 1, 2, 3 and MC Construction

Code Case 1644-3 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: The maximum measured ultimate tensile strength of the component support material should not exceed 170 Ksi.

1644-4	03-01-76 08-13-76	Additional Materials for Component Supports and Alternate Design Requirements for Bolted Joints, Section III, Division 1, Subsection NF, Class 1, 2, 3 and MC Construction

Code Case 1644-4 was acceptable subject to the following conditions in addition to those specified in the Code Case: The maximum measured ultimate tensile strength (UTS) of the component support material should not exceed 170 Ksi in view of the susceptibility of high-strength materials to brittleness and stress corrosion cracking. Certain applications may exist where a UTS value of up to 190 Ksi could be considered acceptable for a material and, under this condition, the Design Specification should specify impact testing for the material. For these cases, it should be demonstrated by the applicant that (1) the impact test results for the material meet code requirements and (2) the material is not subject to stress corrosion cracking by virtue of the fact that (a) a corrosive environment is not present and (b) the component that contains the material has essentially no residual stresses or assembly stresses, and it does not experience frequent sustained loads in service.

1644-5	08-13-76 03-03-77	Additional Materials for Component Supports and Alternate Design Requirements for Bolted Joints, Section III, Division 1, Subsection NF, Class 1, 2, 3 and MC Construction

Code Case 1644-5 was acceptable subject to the following conditions in addition to those specified in the Code Case: The maximum measured ultimate tensile strength (UTS) of the component support material should not exceed 170 Ksi in view of the susceptibility of high-strength materials to brittleness and stress corrosion cracking. Certain applications may exist where a UTS value of up to 190 Ksi could be considered acceptable for a material and, under this condition, the Design Specification should specify impact testing for the material. For these cases, it should be demonstrated by the applicant that (1) the impact test results for the material meet code requirements and (2) the material is not subject to stress corrosion cracking by virtue of the fact that (a) a corrosive environment is not present and (b) the component that contains the material has essentially no residual stresses or assembly stresses, and it does not experience frequent sustained loads in service.

1644-6	03-03-77 11-21-77	Additional Materials for Component Supports and Alternate Design Requirements for Bolted Joints, Section III, Division 1, Subsection NF, Class 1, 2, 3 and MC Construction

Code Case 1644-6 was acceptable subject to the following conditions in addition to those specified in the Code Case: The maximum measured ultimate tensile strength (UTS) of the component support material should not exceed 170 Ksi in view of the susceptibility of high-strength materials to brittleness and stress corrosion cracking. Certain applications may exist where a UTS value of up to 190 Ksi could be considered acceptable for a material and, under this condition, the Design Specification should specify impact testing for the material. For these cases, it should be demonstrated by the applicant that (1) the impact test results for the material meet code requirements and (2) the material is not subject to stress corrosion cracking by virtue of the fact that (a) a corrosive environment is not present and (b) the component that contains the material has essentially no residual stresses or assembly stresses, and it does not experience frequent sustained loads in service.

1644-7 (N-71-7)	11-21-77 05-15-78	Additional Materials for Component Supports, Section III, Division 1, Subsection NF, Class 1, 2, 3 and MC Component Supports

Code Case 1644-7 was acceptable subject to the following conditions in addition to those specified in the Code Case: The maximum measured ultimate tensile strength (UTS) of the component support material should not exceed 170 Ksi in view of the susceptibility of high-strength materials to brittleness and stress corrosion cracking. Certain applications may exist where a UTS value of up to 190 Ksi could be considered acceptable for a material and, under this condition, the Design Specification should specify impact testing for the material. For these cases, it should be demonstrated by the applicant that

(1) the impact test results for the material meet code requirements and (2) the material is not subject to stress corrosion cracking by virtue of the fact that (a) a corrosive environment is not present and (b) the component that contains the material has essentially no residual stresses or assembly stresses, and it does not experience frequent sustained loads in service.

1644-8 (N-71-8)	05-15-78 01-07-80	Additional Materials for Component Supports, Section III, Division 1, Subsection NF, Class 1, 2, 3 and MC Component Supports

Code Case 1644-8 was acceptable subject to the following conditions in addition to those specified in the Code Case: The maximum measured ultimate tensile strength (UTS) of the component support material should not exceed 170 Ksi in view of the susceptibility of high-strength materials to brittleness and stress corrosion cracking. Certain applications may exist where a UTS value of up to 190 Ksi could be considered acceptable for a material and, under this condition, the Design Specification should specify impact testing for the material. For these cases, it should be demonstrated by the applicant that (1) the impact test results for the material meet code requirements and (2) the material is not subject to stress corrosion cracking by virtue of the fact that (a) a corrosive environment is not present and (b) the component that contains the material has essentially no residual stresses or assembly stresses, and it does not experience frequent sustained loads in service.

1644-9 (N-71-9)	01-07-80 05-11-81	Additional Materials for Component Supports Fabricated by Welding, Section III, Division 1, Subsection NF, Class 1, 2, 3, and MC Component Supports

Code Case 1644-9 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: In the last sentence of paragraph 5.3, reference should be made to paragraph 4.5.2.2, "Alternate Atmosphere Exposure Time Periods Established by Test," of the AWS D.1.1 Code for the evidence presented to and accepted by the Authorized Inspector concerning exposure of electrodes for longer periods of time.

1682	01-29-75 08-11-75	Alternate Rules for Material Manufacturers and Suppliers, Section III, Subarticle NA-3700
1714	08-11-75 07-11-77[4]	Postweld Heat Treatment of P-1 Material, Section III, Class MC
1714-1 (N-102-1)	07-11-77[4] 08-28-78	Postweld Heat Treatment of P-1 Material, Section III, Class MC
1722	11-03-75 01-08-79	Vacuum, Carbon Deoxidized SA-508 Forgings, Section III, Division 1, and VIII, Division 1 and 2
1741	12-22-75 01-14-77	Interim Rules for the Required Number of Impact Tests for Rolled Shapes, Section III, Division 1, Subsection NF, Component Supports
1755	04-26-76 01-14-77	Alternative Rules for Examination of Welds in Piping, Class 1 and 2 Construction, Section III, Division 1
1759	08-13-76 05-15-78	Material for Internal Pressure Retaining Items for Pressure Relief Valves, Section III, Division 1, Class 1, 2, and 3

Code Case 1759 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: Applicants using this Case should also use Code Case 1711 for the design of pressure relief valves.

N-188	08-29-77 05-15-78	Use of Welded Ni-Fe-Cr-Mo-Cu (Alloy 825) and Ni-Cr-Mo-Cb (Alloy 625) Tubing, Section III, Division 1, Class 3
N-207	03-20-78 03-19-79	Use of Modified SA-479 Type XM-19 for Section III, Division 1, Class 1, 2 or 3 Construction
N-224	11-20-78 05-11-81	Use of ASTM A500 Grade B and ASTM A501 Structural Tubing for Welded Attachments for Section III, Class 2 and 3 Construction
N-242	04-12-79 04-10-80	Materials Certification, Section III, Division 1, Classes 1, 2, 3, MC, and CS Construction

Code Case N-242 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: Applicants should identify the components and supports requiring the use of paragraphs 1.0 through 4.0 of the Code Case in their Safety Analysis Reports.

N-249	01-07-80 05-11-81	Additional Materials for Component Supports Fabricated Without Welding, Section III, Division 1, Subsection NF, Class 1, 2, 3 and MC Component Supports

Code Case N-249 was acceptable subject to the following condition in addition to those conditions specified in the Code Case: Footnote 2 of the Code Case should apply to all materials listed in Tables 1, 2, 3, 4, and 5 of the Code Case and should be so indicated on line 5 of the "Reply."

4. Code Cases for Class 1 components that are not on the approved list of this guide (paragraph C.1) or other regulatory guides, or for which authorization by the Commission has not been granted, are not acceptable for Class 1 components.

5. Code Cases for other classes of components that are not on the approved list of this guide (paragraph C.1) or other regulatory guides should be considered not acceptable on a generic basis.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the use of this regulatory guide.

1. Except for those Code Cases that have been annulled by action of the ASME Council, the NRC staff has found the Code Cases listed in this regulatory guide under regulatory position C.1 acceptable for appropriate use. Other Code Cases may be considered for use in accordance with footnote 6 of the Codes and Standards rule, §50.55a of 10 CFR Part 50.

2. Components ordered to a specific version of a Code Case need not be changed because a subsequent revision of the Code Case is listed as the approved version in this guide.

3. Components ordered to a Code Case that was previously approved for use need not be changed because the Code Case has been subsequently annulled.

4. Code Cases on the approved list may be applied to components that were in process of construction prior to the effective date of the Code Case within the limits specified in the Code Case and applicable regulations or recommended in other regulatory guides.

ARTICLE XVII-1000

XVII-1100 INTRODUCTION

XVII-1110 SCOPE

The Articles of this Appendix provide rules for the design of linear type supports by either linear elastic analysis (XVII-2000) or plastic (limit) analysis (XVII-4000). Linear elastic analytical procedures are also provided (XVII-3000) for the design of members and connections which will be subjected to high cycle fatigue conditions in service.

XVII-1120 DESIGN BASIS

XVII-1121 Linear Elastic Analysis

The rules for linear elastic analysis are based on the specified minimum yield strength values at temperature of the materials used in constructing linear type supports which are set forth in Tables I-2.1, I-2.2, I-13.1, and I-13.3. The allowable stresses are determined in XVII-2000 by applying design factors, dependent on the structural member involved, to these specified minimum yield strength values.

XVII-1122 High Cycle Fatigue Analysis

The rules for designing linear type supports given in XVII-3000 are essentially the same as those given in XVII-2000 for linear elastic analysis except that the maximum range of stress, namely, the difference between the minimum and maximum value of the stress throughout each cycle, and the frequency with which the support will be subjected to this range of stress, shall be taken into consideration when so stipulated by the Design Specifications (NA-3250).

XVII-1123 Plastic Analysis

The rules for plastic (limit) analysis given in XVII-4000 permit proportioning linear type supports on the basis of plastic design by determining their lower-bound collapse loads. The requirements set forth in XVII-2000 governing allowable stresses to be used in designing linear type supports are waived when the plastic design procedure is employed but all other pertinent provisions of XVII-2000 shall apply.

XVII-1200 NOMENCLATURE AND NUMBERING OF EQUATIONS

XVII-1210 NOMENCLATURE

Except where symbols are used in the text of the Articles which follow to represent the value of complex algebraic expressions, the symbols adopted in the Appendix are defined as follows:

A_b = nominal body area of a fastener, sq. in.
A_f = area of compression flange, sq. in.
A_{st} = cross-sectional area of stiffener or pair of stiffeners, sq. in.
A_w = area of girder web, sq. in.
C = ratio of bolt tensile strength to tensile strength of connected part
C_b = bending coefficient dependent upon moment gradient
C_c = column slenderness ratio dividing elastic and inelastic buckling
C'_c = effective column slenderness ratio
C_m = coefficient applied to bending term in interaction formula and dependent upon column curvature caused by applied moments
C_v = ratio of critical web stress, according to the linear buckling theory, to the shear yield stress of web material
C_1 = ratio of beam yield stress to column yield stress
C_2 = ratio of column yield stress to stiffener yield stress

CASE EXHIBIT 768

Winter 1982 Addenda

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ASME BOILER AND PRESSURE VESSEL CODE

An American National Standard

SECTION III — DIVISION 1
Subsection NF

Business & Technology

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1980 Edition

This is the sixth and last Addenda to be published to the 1980 Edition of Section III, Division 1 — Subsection NF. Previous Addenda were published in Summer 1980, Winter 1980, Summer 1981, Winter 1981, and Summer 1982.

NF-1121 *Revise to read:*

NF-1121 Rules for Supports

The rules of Subsection NF provide requirements for new construction and include consideration of mechanical stresses and effects which result from the constraint of free-end displacements and anchor point motions defined in NF-3121.2 and NF-3121.13 but not thermal or peak stresses.

NF-2123 *Revise to read:*

NF-2123 Design Stress Intensity and Allowable Stress Values

When the procedures of design by analysis (NF-3220) are employed, the applicable design stress intensity values S_m listed in Tables I-1.0 of Appendix I shall be used. When the procedures of linear elastic analysis (NF-3230) are employed, the allowable stress values shall be the applicable yield strength values S_y listed in the tables of Appendix I as modified by the design factors given in NF-3322.

NF-2130 *Revise subparagraph* (a) *to read:*

(a) Material used in the construction of component supports shall be certified. Certified Material Test Reports in accordance with NCA-3867.4 shall be provided for material used for primary members for Class 1 Plate and Shell Type Supports and Class 1 Linear Type Supports. Material for other classes of component supports and all classes of component standard supports shall be provided with Certified Material Test Reports when impact testing is required (NF-2311). Copies of these certificates shall be provided with the component support.

NF-2311 *Revise in its entirety, adding footnote 6, to read:*

NF-2311 Supports for Which Impact Testing of Material is Required[2]

(a) Support materials shall be impact tested in accordance with the requirements listed below.

(1) Integral attachments to the component (NF-1222) shall meet the requirements for impact testing stipulated for such components in the applicable Subsection.

(2) Class 1 component supports shall meet the requirements of NF-2300.

(3) For Class 1 piping supports, Class 1 component standard supports, and all other types and Classes of supports, the Design Specification (NCA-3250) shall state whether or not impact testing is

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ARTICLE NF-3000
DESIGN

NF-3100 GENERAL DESIGN REQUIREMENTS

NF-3110 LOADING CRITERIA

NF-3111 Loading Conditions

The loadings that shall be taken into account in designing a piping or component support include, but are not limited to, those in (a) through (g) below:

(a) weight of the piping or component and normal contents under operating or test conditions, including loads due to static and dynamic head and fluid flow effects;

(b) weight of the piping or component support;

(c) superimposed loads and reactions induced by the supported system components;

(d) dynamic loads, including loads caused by earthquake and vibration;

(e) effects from component or piping thermal expansion;

(f) anchor and support movement effects;

(g) environmental loads such as wind and snow loads.

NF-3112 Design Loadings

The Design Loadings shall be established in accordance with NCA-2142.1 and the following subparagraphs.

NF-3112.1 Design Temperature. The specified Design Temperature shall be established in accordance with NCA-2142.1(b). The metal temperature shall be determined by computation using accepted heat transfer procedures or by measurement from equipment in service under equivalent operating conditions. In lieu of heat transfer analysis or measurements, the component or piping Design Temperature may be used. In no case shall the temperature at the surface of the metal exceed the maximum temperature listed in Tables I-11.0, I-12.0, and I-13.0, or exceed the maximum temperature limitations specified elsewhere in this Subsection.

NF-3112.2 Design Mechanical Loads. The specified Design Mechanical Loads shall be established in accordance with NCA-2142.1(c), and shall include all loads from the component or piping acting on the support.

NF-3113 Service Conditions

Each service condition to which the piping or component may be subjected shall be categorized in accordance with NCA-2142, and Service Limits [NCA-2142.2(b)] shall be designated in the Design Specification in such detail as will provide a complete basis for design in accordance with this Article.

NF-3114 Test Conditions

(In course of preparation.)

NF-3120 DESIGN CONSIDERATIONS

NF-3121 Terms Relating to Design by Analysis

NF-3121.1 General Considerations

(a) Terms that are common to the design by stress analysis of Plate and Shell Type, Linear Type, and Standard Supports are defined in NF-3121.2 through NF-3121.16 below.

(b) Terms unique to the design by stress analysis of Plate and Shell Type Supports are defined in NF-3212.

(c) Terms unique to the design by stress analysis of Linear Type Supports are defined in NF-3313.

NF-3121.2 Primary Stress. Primary stress is any normal stress or shear stress developed by an imposed loading which is necessary to satisfy the laws of equilibrium of external and internal forces and moments. The basic characteristic of a primary stress is

that it is not self-limiting. Primary stresses which considerably exceed the yield strength S_y will result in failure or, at least, in gross distortion. A thermal stress is not classified as a primary stress. A general primary membrane stress is one which is so distributed in the support that no redistribution of load occurs in the support as a result of yielding. Examples of primary stress are general membrane stress in a circular cylindrical shell due to a uniformly distributed axial load, and bending stress in a cantilever beam due to a normal end load. In addition to the above, for piping and component supports, stresses induced in the support by restraint of free end displacement [NF-3111(e) and (f)] and anchor motion of piping are considered primary stresses.

NF-3121.3 Secondary Stress. Secondary stress is a normal stress or a shear stress developed by the constraint of adjacent material or by self-constraint of the structure. The basic characteristic of a secondary stress is that it is self-limiting. Local yielding and minor distortions can satisfy the conditions which cause the stress to occur, and failure from one application of the stress is not to be expected. An example of secondary stress is bending stress at a gross structural discontinuity.

NF-3121.4 Peak Stress. Peak stress is that increment of stress which is additive to the primary plus secondary stresses by reason of local discontinuities or local thermal stress, including the effects, if any, of stress concentrations. The basic characteristic of a peak stress is that it does not cause any noticeable distortion and is objectionable only as a possible source of a fatigue crack or brittle fracture. A stress which is not highly localized falls into this category if it is of a type which cannot cause noticeable distortion. Evaluation of peak stresses is not required by this Subsection.

NF-3121.5 Normal Stress. Normal stress is the component of stress normal to the plane of reference. This is also referred to as direct stress. Usually the distribution of normal stress is not uniform through the thickness of a part, so this stress is considered to be made up in turn of two components, one uniformly distributed and equal to the average value of stress across the thickness under consideration, and the other varying from this average value with the location across the thickness.

NF-3121.6 Shear Stress. Shear stress is the component of stress tangent to the plane of reference.

NF-3121.7 Membrane Stress. Membrane stress is the component of normal stress which is uniformly distributed and equal to the average of stress across the thickness of the section under consideration.

NF-3121.8 Bending Stress. Bending stress is the variable component of normal stress. The variation may or may not be linear across the thickness.

NF-3121.9 Total Stress. Total stress is the sum of the primary and secondary stress contributions. Recognition of each of the individual contributions is essential to establishment of appropriate stress limitations.

NF-3121.10 Critical Buckling. Critical buckling occurs when a support is loaded to a state at which an infinitesimal additional load or disturbance causes the support to change from an equilibrium condition to one of instability.

NF-3121.11 Thermal Stress. Thermal stress is a self-equilibrating stress produced by a nonuniform distribution of temperature or by differing thermal coefficients of expansion. Thermal stress is developed in a solid body whenever a volume of material is prevented from assuming the size and shape that it normally would under a change in temperature. Evaluation of thermal stresses in the support is not required by this Subsection.

NF-3121.12 Free End Displacement. Free end displacement consists of the relative motions that would occur between an attachment and connected structure or equipment if the two members were separated and permitted to move.

NF-3121.13 Anchor Point Motion Stress. Anchor point motion stresses are those stresses resulting from the differential motion of piping or component support points. An example is differential building settlement.

NF-3121.14 Gross Structural Discontinuity. Gross structural discontinuity is a geometric or material discontinuity which affects the stress or strain distribution through the entire thickness of the member. Gross discontinuity type stresses are those portions of the actual stress distributions that produce net bending and membrane force resultants when integrated through the thickness. Examples of gross structural discontinuities are junctions between parts of different diameters or thicknesses and flange-to-shell junctions.

NF-3121.15 Limit Analysis — Collapse Load. The methods of limit analysis are used to compute the maximum load or combination of loads a structure made of ideally plastic (nonstrain-hardening) material can carry. The deformations of an ideally plastic

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ORGANIZATION OF SECTION III

1. GENERAL

Section III consists of Division 1 and Division 2. Both Divisions are broken down into Subsections which are designated by capital letters preceded by the letter "N" for Division 1 and by the letter "C" for Division 2. The following nine books make up the two Divisions.

Subsection NCA — General Requirements for Division 1 and Division 2

Division 1
- Subsection NB — Class 1 Components
- Subsection NC — Class 2 Components
- Subsection ND — Class 3 Components
- Subsection NE — Class MC Components
- Subsection NF — Component Supports
- Subsection NG — Core Support Structures
- Appendices

Division 2 — Code for Concrete Reactor Vessels and Containments

The Division 2 book includes Subsection CB — Concrete Reactor Vessels. Subsection CC — Concrete Containments, and Division 2 Appendices.

2. SUBSECTIONS

Subsections are divided into Articles. Subarticles, paragraphs, and, where necessary, subparagraphs and subsubparagraphs.

3. ARTICLES

Articles are designated by the applicable letters indicated above for the Subsections followed by Arabic numbers, such as NB-1000 or CB-2000. Where possible, Articles dealing with the same topics are given the same number in each Subsection in accordance with the following general scheme:

Article Number	Title
1000	Introduction or Scope
2000	Material
3000	Design
4000	Fabrication and Installation
5000	Examination
6000	Testing
7000	Overpressure Protection
8000	Nameplates, Stamping, and Reports

The numbering of Articles and the material contained in the Articles may not, however, be consecutive. Due to the fact that the complete outline may cover phases not applicable to a particular Subsection or Article, the rules have been prepared with some gaps in the numbering.

4. SUBARTICLES

Subarticles are numbered in units of 100, such as NB-1100 or CB-1200.

5. SUBSUBARTICLES

Subsubarticles are numbered in units of 10, such as NB-2130, and generally have no text. When a number such as NB-1110 is followed by text, it is considered a paragraph.

6. PARAGRAPHS

Paragraphs are numbered in units of 1, such as NB-2131 or CB-2132.

7. SUBPARAGRAPHS

Subparagraphs, when they are *major* subdivisions of a paragraph, are designated by adding a decimal followed by one or more digits to the paragraph number, such as NB-1111.1 or CB-1111.2. When they are *minor* subdivisions of a paragraph, subparagraphs may be designated by lowercase letters in parentheses, such as NB-1111(a) or CB-1111(b).

8. SUBSUBPARAGRAPHS

Subsubparagraphs are designated by adding lowercase letters in parentheses to the *major* subparagraph numbers, such as NB-1111.1(a) or CB-1111.1(b). When further subdivisions of *minor* subparagraphs are necessary, subsubparagraphs are designated by adding Arabic numerals in parentheses to the subparagraph designation, such as NB-1111(a)(1) or CB-1111(a)(2).

9. REFERENCES

References used within Section III generally fall into one of the following four categories:

A. References to Other Portions of Section III

When a reference is made to another Article, Subarticle, or paragraph, all numbers subsidiary to that reference shall be included. For example, reference to NB-3000 includes all material in Article NB-3000; reference to NB-3200 includes all material in Subarticle NB-3200; reference to NB-3250 includes all paragraphs NB-3251 through NB-3256.

B. References to Other Sections

Other Sections referred to in Section III are:

Section II, Material Specifications. When a requirement for a material, or for the examination or testing of a material, is to be in accordance with a specification such as SA-105, SA-370, or SB-160, the reference is to material specifications in Section II. These references begin with the letter "S".

Section V, Nondestructive Examination. Section V references begin with the letter "T" and relate to the nondestructive examination of material or welds.

Section IX, Welding and Brazing Qualifications. Section IX references begin with the letter "Q" and relate to welding and brazing requirements.

Section XI, Inservice Inspection of Nuclear Power Plant Components. When a reference is made to inservice inspection, the rules of Section XI shall apply.

C. Reference to Specifications and Standards Other Than Published in Code Sections

(1) Specifications for examination methods and acceptance standards to be used in connection with them are published by the American Society for Testing and Materials. At the time of publication of Section III, some such specifications were not included in Section II of this Code. A reference to ASTM E 71-64 refers to the specification so designated by and published by ASTM, 1916 Race St., Philadelphia, Pa. 19103.

(2) Dimensional standards covering products such as valves, flanges, and fittings are approved by the American National Standards Institute[1] and published by the American Society of Mechanical Engineers. When a product is to conform to such a standard, for example ANSI B16.5, the standard is approved by the American National Standards Institute. The applicable year of issue is that suffixed to its numerical designation in Table NB-3132-1, for example ANSI B16.5-1968. ANSI-approved standards published by the American Society of Mechanical Engineers are available from ASME, 345 East 47th St., New York, N.Y. 10017. Other ANSI-approved standards are available from their publishers or the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

(3) Dimensional and other types of standards covering products such as valves, flanges, and fittings are also published by the Manufacturers Standardization Society of the Valve and Fittings Industry and are known as Standard Practices. When a product is required by these rules to conform to a Standard Practice, for example MSS SP-6, the Standard Practice referred to is published by the Manufacturers Standardization Society of the Valve and Fittings Industry, 1815 North Ft. Meyer Drive, Arlington, Va. 22209. The applicable year of issue of such a Standard Practice is that suffixed to its numerical designation in Table NB-3132-1, for example MSS SP-6-1963.

(4) Specifications for welding and brazing materials are published by the American Welding Society, 2501 Northwest 7th St., Miami, Fla. 33125. Specifications of this type are incorporated in Section II and are identified by the AWS designation with the prefix "SF", for example SFA-5.1.

(5) Standards applicable to the design and construction of tanks and flanges are published by the American Petroleum Institute and have designations such as API-620 and API-2000. When documents so designated are referred to in Section III, they are standards published by the American Petroleum Institute.

D. References to Appendices

Two types of Appendices are used in Section III and are designated Mandatory and Nonmandatory.

(1) Mandatory Appendices contain requirements which must be followed in construction: such references are designated by a Roman numeral followed by Arabic numerals. References to Table I-1.2 or II-1100, for example, relate to the Mandatory Appendices.

(2) Nonmandatory Appendices provide information or guidance for the use of Section III: such references are designated by a capital letter followed by Arabic numerals. A reference to D-1100, for example, relates to a Nonmandatory Appendix.

[1]The American National Standards Institute (ANSI) was formerly known as the American Standards Association. Standards approved by the Association were designated by the prefix "ASA" followed by the number of the standard and the year of publication. More recently, the American National Standards Institute was known as the United States of America Standards Institute. Standards were designated by the prefix "USAS" followed by the number of the standard and the year of publication. While the letters of the prefix have changed with the name of the organization, the numbers of the standards have remained unchanged.

This code or standard was developed under procedures accredited as meeting the criteria for American National Standards. The Consensus Committee that approved the code or standard was balanced to assure that individuals from competent and concerned interests have had an opportunity to participate. The proposed code or standard was made available for public review and comment which provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

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Meeting of March 6, 1981
Approved by Council, May 11, 1981

This Case shall expire on May 11, 1984
unless previously annulled or reaffirmed.

Case N-71-10
Additional Materials for Component Supports Fabricated by Welding
Section III, Divison 1, Subsection NF Class 1, 2, 3, and MC Component Supports

Inquiry: What materials, in addition to those listed in Tables I-11.0, I-12.0, and I-13.0 of Appendix I of Section III, Division 1, may be used for Class 1, 2, 3, or MC component supports constructed to the requirements of Subsection NF when the items are fabricated by welding?

Reply: It is the opinion of the Committee that as alternatives to the materials listed in the tables of Appendix I referenced in Table NF-2121 (a)-1, the design stress intensity and allowable stress values, the yield strength, and the ultimate tensile strength values,[1] for the material specifications listed in Tables 1, 2, 3, 4, and 5 of this Case may be used in welded construction of Class 1, 2, 3, and MC component supports for Section III, Division 1. These materials may also be used for nonwelded construction.

The following additional requirements shall apply:

[1] The tabulated values of tensile strength and yield strength are those which the Committee believes are suitable for use in design calculations required by Section III, Division 1. At the temperatures above room temperature, the values of tensile strength tend toward an average or expected value which may be as much as 10% above the tensile strength trend curve adjusted to the minimum specified room temperature tensile strength. 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. Neither the tensile strength nor the yield strength values correspond exactly to either "average" or "minimum," as these terms are applied to a statistical treatment of a homogeneous set of data.

Neither the ASME or ASTM Material Specifications nor the rules of Section III, Division 1, require elevated temperature testing for tensile or 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 tensile and yield strength values for [illegible] 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 suggesting the possibility of some error), further investigation by retest or other means should be considered.

1.0 GENERAL REQUIREMENTS

1.1 The requirements of Subsection NF shall be met except as modified by this Case.

2.0 MATERIALS

2.1 Welding is not permitted on carbon and low alloy steels containing more than 0.35% carbon.

2.2 When the Nominal Composition columns in Tables 1 through 4 reference AISI grades, only materials meeting the chemical composition range requirements of the specific AISI grades listed shall be used, with the exception that 0.60% maximum silicon is permitted for castings.

2.3 Materials in Tables 1 through 4 whose nominal composition is referenced as an AISI composition may be accepted as satisfying the requirements of the ASTM specification provided the chemical requirements of the AISI specification are within the specified range of the designated ASTM specification, and certification of the material shall be in accordance with the requirements of the NCA-3867.4 (e) or (f). The term "each piece of stock material" in NCA-3867.4 (e) may be taken to refer to that portion of the material of the same heat and lot which has traceability established by the Manufacturer through his program. Where Certificates of Compliance are acceptable under Subsection NF, testing of each piece is not required.

2.4 When an ASTM specification does not specify either minimum tensile or yield strengths, the values listed in this case shall be met by the material.

2.5 The material shall be furnished in accordance with the requirements of NF-2600.

2.6 The thickness referenced in this Case is the nominal thickness of the weld, the base material or the thinner of the sections being joined, whichever is least. For fillet welds, the nominal thickness is the throat thickness, and

TABLE 3

Yield Strength Values, S_y, for Ferritic Steels for Classes 1, 2, 3, and MC Linear Type Component Supports

Nominal Composition	S-No.	Group No.	Product Form	Specification No.	Type or Grade	Class	Notes	Min. Yield Strength, ksi	Min. Ultimate Tensile Strength, ksi	Yield Strength, ksi (multiply by 1000 to obtain psi) for metal temperatures, °F, not to exceed: 100	200	300	400	500	600	650	700	750	800
Carbon Steels																			
AISI 1015, 1018, 1020	1	1	Bar	A108-79	1015CW, 1018CW, 1020CW	–	1,6	40	60	32.0	29.2	28.3	27.4	–	–	–			–
– – –	1	1	Plate	SA-283	C	–	–	30	55	30.0	27.3	26.6	25.7	–	–	–	–	–	–
– – –	1	1	Plate	A284-77	B	–	–	27.5	55	27.5	25.5	24.3	23.6	–	–	–	–	–	–
– – –	1	1	Pipe	A381-79	–	Y35	–	35	60	35.0	31.9	31.0	30.0	28.3	25.9	25.6	25.2	–	–
– – –	1	1	Tb.Shp.	A500-78	B	–	1	42	58										
– – –	1	1	Tb.Shp.	A500-78	C	–	1	46	62	36.0	32.8	31.9	30.8	29.1	26.6	26.1	25.9	–	–
– – –	1	1	Str.Tb.	A501-76	–	–	–	36	58										
AISI 1015	1	1	Tube	A513-79	1015CW	–	1,6	55	65	32.0	29.2	28.3	27.4	–	–	–	–	–	–
AISI 1020	1	2	Tube	A513-79	1020CW	–	1,6	60	70	32.0	29.2	28.3	27.4	–	–	–	–	–	–
AISI 1025, 1026	1	2	Tube	A513-79	1025CW, 1026CW	–	1,7	65	75	35.0	31.9	31.0	30.0	–	–	–	–	–	–
– – –	1	1	Plate	SA-516	60	–	–	32	60	32.0	29.2	28.3	27.4	25.9	23.6	23.2	23.0	–	–
– – –	1	1	Plate	SA-516	65	–	–	35	65	35.0	31.9	31.0	30.0	28.3	25.9	25.4	25.2	–	–
– – –	1	2	Plate	SA-516	70	–	–	38	70	38.0	34.6	33.7	32.6	30.7	28.1	27.6	27.4	–	–
AISI 1018, 1020, 1022	1	2	Tube	A519-79	1018CW, 1020CW, 1022CW	–	1,6	60	70	32.0	29.2	28.3	27.4	–	–	–	–	–	–
AISI 1018, 1020, 1022			Tube	A519-79	1018HR, 1020HR, 1022HR	–	–	32	50	32.0	29.2	28.3	27.4	–	–	–	–	–	–
AISI 1025, 1026	1	1	Tube	A519-79	1025HR, 1026HR	–	–	35	55	35.0	31.9	31.0	30.0	–	–	–	–	–	–
AISI 1025, 1026	1	2	Tube	A519-79	1025CW, 1026CW	–	1,5,7	65	75	35.0	31.9	31.0	30.0	–	–	–	–	–	–
AISI 1020, 1025, 1030	1	1	Forging	A521-76	–	CC	–	30	60	30.0	27.3	26.6	25.7	24.3	22.2	21.8	21.6	–	–
	1	2	Forging	A521-76	–	CE	–	37	75	37.0	33.7	32.8	31.7	29.9	27.4	26.9	26.6	–	–
– – –	1	1	Pipe	SA-524	I	–	–	35	60	35.0	31.9	31.0	30.0	–	–	–	–	–	–
– – –	1	1	Pipe	SA-524	II	–	–	30	55	30.0	27.3	26.6	25.7	–	–	–	–	–	–
– – –	1	2	Plate	SA-537	–	1	4	45	65	45.0	39.7	36.5	33.7	31.6	30.5	29.7	28.8	–	–
– – –	1	2	Plate	SA-537	–	1	3	50	70	50.0	44.1	40.5	37.5	35.2	33.9	33.0	32.1	–	–
– – –	1	3	Plate	SA-537	–	2	4	55	75	55.0	50.5	47.9	45.8	43.7	43.0	41.5	40.8	–	–
– – –	1	3	Plate	SA-537	–	2	3	60	80	60.0	55.0	52.2	50.0	47.6	46.0	45.2	44.5	–	–
– – –	1	1	Sheet Strip	A570-79	36	–	–	36	53	36.0	32.8	31.9	30.8	29.1	26.6	26.1	25.9	–	–
					45	–	–	45	60	45.0	41.0	39.9	38.5	36.4	33.3	32.6	32.4	–	–

TABLE 3 (Continued)

Yield Strength Values, S_y, for Ferritic Steels for Classes 1, 2, 3, and MC Linear Type Component Supports

Notes:

1. For welded construction the yield strengths tabulated are those for hot rolled material; 32.0 ksi for AISI 1015CW, 1018CW, 1020CW; 35.0 ksi for AISI 1025CW, 1026CW, 8020CW; 36.0 ksi for A500, A501.
2. There is no standard AISI composition 4330. By agreement with the material manufacturer, the carbon content of AISI 4320 can be ordered as 0.27% to 0.33%.
3. Up to 2½ in. inclusive.
4. Over 2½ to 4 in.
5. These materials are limited for use only for component standard supports.
6. Max BHN 215.
7. Max BHN 225.
8. The elongation and reduction of area requirements for this material may be specified at 17% and 35% minimum, respectively.
9. By agreement between Purchaser and Material Manufacturer, these materials may be procured to the lower specified minimum ultimate tensile strength and minimum yield strength values given in this table.
10. For each forging 250 lb. net weight and less., the marking requirements of A 668-79a shall be met by a suitable code or symbol identified by the Manufacturer in his Certificate of Compliance or Certified Material Test Report. The hardness test requirement may be performed only on the tensile test specimen.
11. –
12. Over 5 in. to 8 in.
13. Over 4 in. to 5 in.
14. Plate up to 4 in. incl. and all structural shapes.
15. –
16. Up to 7 in. incl.
17. Up to 4 in. incl.
18. Over 4 in. to 7 in. incl.
19. Over 7 in. to 10 in. incl.
20. Over 2½ in. to 6 in. incl.
21. Max. carbon 0.35%.
22. Up to 1¼ in. incl.
23. –

SERIES IN CIVIL ENGINEERING

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McCormac, *Structural Analysis, Third Edition*
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STEEL STRUCTURES

Design and Behavior

Second Edition

Charles G. Salmon
John E. Johnson
University of Wisconsin-Madison

HARPER & ROW, PUBLISHERS, New York
Cambridge, Hagerstown, Philadelphia, San Francisco
London, Mexico City, São Paulo, Sydney
1817

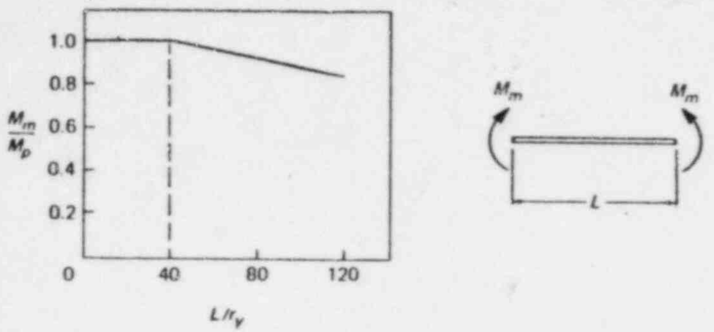

Fig. 12.8.3 Lateral buckling moment for uniform bending. (From Ref. 30; see also Ref. 25)

C_m = factors discussed in Secs. 12.3–12.5

$$P_e = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 EP_y}{F_y(L/r)^2}$$

The reduction in ultimate moment capacity M_m when lateral-torsional buckling influences the ultimate strength interaction may be computed as $F_{cr}S_x$ using the SSRC "Basic" design procedure of Sec. 9.4 with no safety factor applied. This will be consistent with working stress procedures involving AISC Formulas (1.5–6) and (1.5–7).

According to Driscoll et al. (Ref. 30, p. 4.25), such a procedure is overly conservative. According to Ref. 30, "The behavior of beam-columns after lateral-torsional buckling has not yet been fully explored and available information is not sufficient to evaluate the effect of lateral-torsional buckling on rotation capacity. The limited results seem to indicate that for columns of low slenderness ratios ($L/r = 40$ or less) the end moment may not be reduced from the in-plane values significantly and drop off suddenly until a large rotation is reached." In other words, in real structures *without* pin-ended beam-columns the lateral-torsional buckling is restrained and the moment capacity does not drop off as drastically as indicated by the theoretical expressions developed in Chapter 9.

Figure 12.8.3 shows an empirical relationship for the reduction in ultimate moment.

12.9 BIAXIAL BENDING

The ultimate strength of members under axial compression and biaxial bending has received little attention until the last few years. Computer studies such as those of Birnstiel and Michalos [31], Culver [32, 33], Harstead, Birnstiel, and Leu [34], Syal and Sharma [35], Santathadaporn and Chen [36], and Chen and Atsuta [37] illustrate that even with a

number of simplifying assumptions, the analysis is one of considerable complexity. Some tests have been performed [38] which, though limited, have shown agreement with computer studies. Tebedge and Chen [40] have given interaction surfaces in the form of tables for design. The status of work on biaxial bending of compression members is summarized well by Chen and Santathadaporn [39].

Simple plastic theory becomes inadequate when moments exist about two principal axes. When only one moment exists, plastic behavior is exhibited no matter what the value of axial compression. Figure 12.6.3 showed that under such loading the effective plastic moment reduces as axial compression increases, but plastic behavior does occur.

Upon application of an additional moment about the other principal axis, one might consider an interaction surface relating, P, M_x, and M_y. Even for ideal elastic-plastic material, however, present plastic analysis theorems neglect the influence of deformation on equilibrium. For zero length compression members, the concept of an interaction surface (see Fig. 12.9.1) may be thought of as a first step to the ultimate strength analysis under biaxial bending.

While few designers concern themselves greatly about the sequence of load application, nevertheless loading sequence affects ultimate strength. This is also true for uniaxial bending and compression, but it has less effect on that case than for the biaxial loading.

Figure 12.9.2 illustrates several loading sequences to reach point A, a particular value of P, M_x, and M_y. Point A may be reached by the following paths:

(1) Apply P first, then M_y, then M_x (path 0–1–2–A); (2) apply P first, then apply M_x and M_y proportionally (path 0–1–A); (3) apply P, M_x and

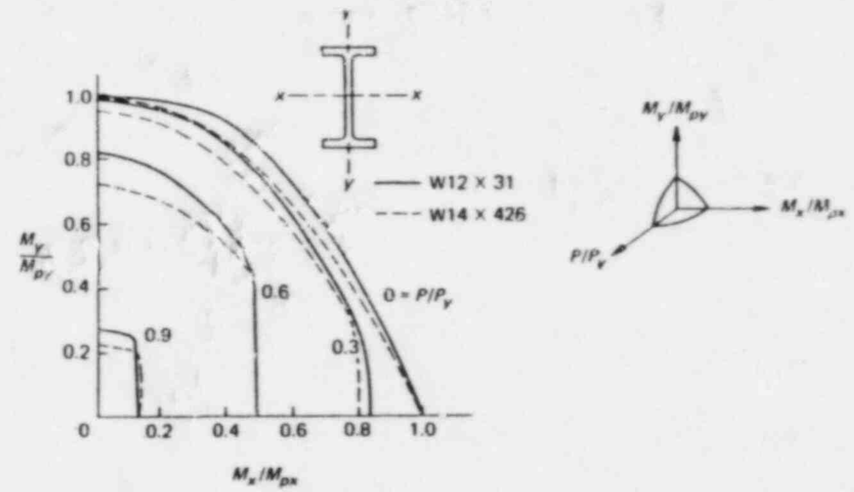

Fig. 12.9.1 Contours on interaction surface for short members where instability does not occur. (Adapted from Birnstiel [38])

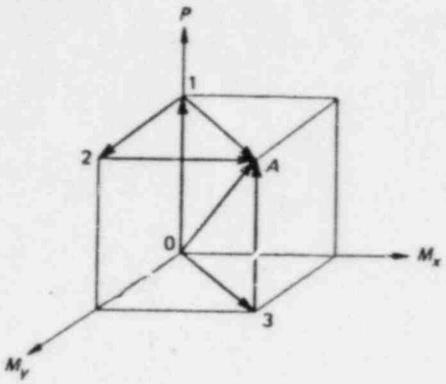

Fig. 12.9.2 Paths of loading for biaxial bending combined with axial force. (Adapted from Chen and Santathadaporn [39])

M_y by increasing magnitude in constant proportion (path O–A); (4) apply M_x and M_y in constant proportion, then apply P (path O–3–A). Other combinations are possible and in general the loading may become applied via any path through space to get from O to A on Fig. 12.9.2. A given section will exhibit a different strength for each path of loading. Nearly all investigators to date (1979) have used proportional loading (path O–A) [38].

To conclude, the ultimate strength of compression members under biaxial bending is not sufficiently well known to make use of it for plastic design of rigid space frames; therefore plastic design should be restricted to planar structures, or ones for which planar behavior represents a reasonable approximation.

For lack of adequate investigation, an interaction formula, such as Eq. 12.8.4, is usually assumed to apply for biaxial bending. Computer studies and some tests indicate that such a procedure is realistic for those cases investigated. Thus the full interaction equation would be

$$\frac{P}{P_{cr}} + \frac{M_x C_{mx}}{M_{mx}(1 - P/P_{ex})} + \frac{M_y C_{my}}{M_{my}(1 - P/P_{ey})} \le 1 \tag{12.9.1}$$

where all terms are as defined following Eq. 12.8.4, except that now the quantities subscripted x and y must be evaluated for bending about the axis indicated by subscript.

12.10 AISC—WORKING STRESS DESIGN CRITERIA

For working stress design, the strength interaction equations, Eqs. 12.8.1 through 12.8.4, may be converted to unit stresses and a factor of safety (FS) applied to bring them into the service load range.

Stability Interaction Criterion

The ultimate strength interaction equation, Eq. 12.8.4, including lateral-torsional buckling is

$$\frac{P_u}{P_{cr}} + \frac{M_{ui}}{M_m} \frac{C_m}{(1 - P_u/P_e)} = 1 \tag{12.8.4}$$

where P_u and M_{ui} are the axial force and primary bending moment, respectively, that occur *when failure is imminent.* When both the numerator and denominator are divided by a factor (FS) to bring all terms into the service load range,

$$\frac{P_u/(A_g \text{FS})}{P_{cr}/(A_g \text{FS})} + \frac{M_{ui}/[S(\text{FS})]}{M_m/[S(\text{FS})]} \frac{C_m}{\left[1 - \dfrac{P_u/(A_g \text{FS})}{P_e/(A_g \text{FS})}\right]} = 1.0 \tag{12.10.1}$$

or

$$\frac{P/A_g}{P_{cr}/(A_g \text{FS})} + \frac{M/S}{M_m/[S(\text{FS})]} \frac{C_m}{\left[1 - \dfrac{P/A_g}{P_e/(A_g \text{FS})}\right]} = 1.0 \tag{12.10.2}$$

which gives as a design requirement,

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \cdot \frac{C_m}{(1 - f_a/F'_e)} \le 1.0 \tag{12.10.3}$$

for *uniaxial* bending and compression.

By analogy, for bending about both x- and y-axes, Eq. 12.10.3 would become

$$\frac{f_a}{F_a} + \frac{f_{bx} C_{mx}}{F_{bx}(1 - f_a/F'_{ex})} + \frac{f_{by} C_{my}}{F_{by}(1 - f_a/F'_{ey})} \le 1.0 \tag{12.10.4}$$

which is the stability interaction equation, AISC Formula (1.6–1a), where

- $f_a = P/A_g$ = nominal axial compression stress at service load
- f_{bx}, f_{by} = flexural stresses at service load based on primary bending moment about the x- and y-axes, respectively
- F_a = allowable compression stress considering the member as loaded by axial compression only
- F_{bx}, F_{by} = allowable flexural stresses for the x- and y-axes, respectively, considering the member loaded in bending only. According to the definition of C_b in AISC–1.5.1.4.5(2.), when the stability equation, Eq. 12.10.4, is used for *braced frames* $C_b = 1.0$, but when Eq. 12.10.4 is used for *unbraced frames*, $C_b = 1.75 + 1.05(M_1/M_2) + 0.3(M_1/M_2)^2 \le 2.3$