



REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.130

SERVICE LIMITS AND LOADING COMBINATIONS FOR CLASS 1 PLATE-AND-SHELL-TYPE SUPPORTS

A. INTRODUCTION

Purpose

This regulatory guide delineates levels of service limits and appropriate combinations of loadings associated with normal operation, postulated accidents, and specified seismic events for the design of Class 1 plate-and-shell-type component and piping supports, as defined in Subsection NF of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Power Plant Components" (Ref. 1), that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable. This guide applies to light-water-cooled reactors.

Applicable Rules and Regulations

General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," of the *Code of Federal Regulations* (10 CFR) (Ref. 2) requires that the design bases for structures, systems, and components important to safety reflect appropriate combinations of the effects of normal and accident conditions with the effects of natural phenomena such as earthquakes. The failure of members designed to support safety-related components and piping could jeopardize the ability of the supported component or piping to perform its safety function. This is also applicable under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Reg. 3)

Purpose of Regulatory Guides

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not

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Electronic copies of this regulatory guide, previous versions of this guide, and other recently issued guides are available through the NRC's public Web site under the Regulatory Guides document collection of the NRC Library at <http://www.nrc.gov/reading-rm/doc-collections/>. The regulatory guide is also available through the NRC's Agencywide Documents Access and Management System (ADAMS) at <http://www.nrc.gov/reading-rm/adams.html>, under ADAMS Accession No. ML13141A667.

required. Methods and solutions that differ from those set forth in regulatory guides will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

Information Collection Requirements

This regulatory guide contains information collections that are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011 and 3150-0151. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Reason for Revision

Revision 3 of RG 1.130 updates the NRC's approval of the ASME Boiler and Pressure Vessel Code (ASME B&PV Code), Section III, Division 1, 2007 Edition through the 2008 Addenda, as one acceptable means for delineating levels of service limits and appropriate combinations of loadings associated with normal operation, postulated accidents, and specified seismic events for the design of Class 1 plate-and-shell-type component and piping supports. Revision 2 of RG 1.130 approved the 2001 Edition through the 2003 Addenda of the ASME B&PV Code. None of the changes from the 2001 Edition through the 2003 Addenda, to the 2007 Edition through the 2008 Addenda, were in the areas covered by RG 1.130. In addition, Revision 3 of RG 1.130 includes editorial changes to improve clarity and provide a new standardized format for regulatory guides.

Background

Load-bearing members classified as component and piping supports are essential to the safety of nuclear power plants because they hold components and piping in place during loadings associated with normal and upset plant conditions under the stress of specified seismic events, thereby permitting system components and piping to function properly. Load-bearing members also prevent excessive movement of components and piping during the loadings associated with emergency and faulted plant conditions combined with a specified seismic event or other natural phenomena, thereby helping to mitigate system damage. Component and piping supports are deformation-sensitive because large deformations can significantly change the stress distribution in the support system and its supported components and piping.

To provide a consistent level of safety, the ASME Code classification for component and piping supports should, as a minimum, be the same as that of the supported components and piping. This guide delineates levels of service limits and loading combinations, as well as supplementary criteria, for Class 1 plate-and-shell-type component and piping supports, as defined by NF-1212 of Section III of the ASME Code. This guide does not address snubbers.

Subsection NF of Section III permits the use of three methods for the design of Class 1 plate-and-shell-type component and piping supports: (1) linear elastic analysis, (2) load rating, and (3) experimental stress analysis. For each method, the ASME Code delineates allowable stress or loading limits for various ASME Code service levels, as defined by NF-3113 and NCA-2142.4(b) of Section III, so that these limits can be used in conjunction with the resultant loadings or stresses from the appropriate plant conditions. Because the ASME Code does not specify loading combinations, guidance is needed to provide a consistent basis for the design of supports.

Component and piping supports considered in this guide are located within seismic Category I structures and, therefore, are assumed to be protected against loadings from natural phenomena (or manmade hazards) other than the specified seismic events. Thus, only the specified seismic events need to be considered in combination with the loadings associated with plant conditions to develop appropriate loading combinations. Loadings caused by any natural phenomena other than seismic events should be considered on a case-by-case basis.

1. Design by Linear Elastic Analysis

Tables 2A, 2B, 4, U, and Y-1 in Subpart 1 of Part D of Section II and Tables 1, 3, 4, and 5 of the latest accepted versions¹ of ASME Code Cases N-71, “Additional Materials for Subsection NF, Class 1,2,3, and MC Component supports Fabricated by Welding, Section III, Division 1,” and N-249, “Additional Materials for Subsection NF, Class 1,2,3, and MC Component Supports Fabricated without Welding, Section III, Division 1,” provide the material properties when the linear elastic analysis method is used to design Class 1 plate-and-shell-type component and piping supports. These tables list values at various temperatures for the design stress intensity S_m , the minimum yield strength S_y , and the ultimate tensile strength S_u .

NF-3522 and NF-3622 limit the primary stress for service levels A, B, and C to less than or equal to one-half the critical buckling strength of the component or piping support at temperature. Guidance in F-1331.5(a) limits the increase for service level D to two-thirds of the critical buckling strength of the component or piping support at temperature. Because buckling prevents “shakedown” in a load-bearing member, it must be regarded as controlling for the level A through level D service limits. Also, buckling is the result of the interaction of the geometry of the load-bearing member and its material properties (i.e., elastic modulus E and minimum yield strength S_y). Because both of these material properties change with temperature, calculation of the critical buckling stresses should use the values of E and S_y of the support material at temperature.

Allowable service limits for bolted connections are derived on a different basis, which varies with the size of the bolt. For this reason, the increases permitted by NF-3221.2 and F-1332 of Section III do not directly apply to bolts and bolted connections. For bolts, allowable increases for service levels B, C and D are specified in NF-3225.

2. Design by Load Rating

NF-3280 specifies load ratings for service level A, B, and C limits. F-1332.7 specifies the load rating for the service level D limit.

3. Design by Experimental Stress Analysis

Although II-1430 in Appendix II to Section III defines the test collapse load for the experimental stress analysis method, it does not delineate the method’s design limits or various operating condition categories. The interim method described in this guide remedies this deficiency.

¹ Regulatory Guide 1.84, “Design, Fabrication, and Materials Code Case Acceptability, ASME Section III,” provides guidance for the acceptability of ASME Section III Code Cases and their revisions, including Code Cases N-71 and N-249. Code Cases identified as “Conditionally Acceptable Section III Code Cases” are acceptable, provided that they are used with the identified limitations or modifications.

4. Large Deformations

The design of component and piping supports is an integral part of the design of a system and its components and piping. A complete and consistent design is possible only when the interaction between the system, component, piping, and support is properly considered. When all four elements are evaluated on an elastic basis, the interaction is usually valid because individual deformations are small. However, if the design process uses plastic analysis methods, large deformations may occur that would result in substantially different stress distributions.

For the evaluation of level D service limits, Appendix F to Section III permits the use of plastic analysis methods in certain acceptable combinations for all four elements. The selection of these acceptable combinations assumes that component and piping supports are more deformation-sensitive (i.e., their deformation in general will have a large effect on the stress distribution in the system and its components and piping).

Because large deformations always affect stress distribution, care should be exercised even when using the plastic analysis method in the methodology combination approved in Appendix F. This is especially important for identifying buckling or instability problems when the change of geometry should be considered to avoid erroneous results.

5. Function of Supported System

In selecting the level of service limits for different loading combinations, the designer should take into account the function of the supported system. To ensure that systems whose normal function is to prevent or mitigate the consequences of events associated with an emergency or faulted plant condition (e.g., the function of the emergency core cooling system during faulted plant conditions) will operate properly regardless of plant condition, the use of ASME Code Section III level A or B service limits of Subsection NF (or other justifiable limits provided by the Code) is appropriate.

6. Deformation Limits

Because component and piping supports are deformation-sensitive load-bearing elements, satisfying the service limits of Section III will not automatically ensure their proper function. If stated in the ASME Code design specification, deformation limits may be the controlling criterion. By contrast, if a particular plant condition does not require the function of a component or piping support, the stresses or loads resulting from the loading combinations under the particular plant condition do not need to satisfy the design limits for the plant condition.

7. Definitions

Critical buckling strength. The strength at which lateral displacements start to develop simultaneously with in-plane or axial deformations.

Design condition. The loading condition defined by NF-3112 of Section III of the ASME Boiler and Pressure Vessel Code.

Emergency plant conditions. Those operating conditions that have a low probability of occurrence.

Faulted plant conditions. Those operating conditions associated with postulated events of extremely low probability.

Levels of service limits. Four levels of service limits—A, B, C, and D—defined by Section III of the ASME Boiler and Pressure Vessel Code for the design of loadings associated with different plant conditions for components and piping and component and piping supports in nuclear power plants.

Normal plant conditions. Those operating conditions that occur in the course of system startup, operation, hot standby, refueling, and shutdown, with the exception of upset, emergency, or faulted plant conditions.

Operating-basis earthquake. Seismic event defined in Appendix A, “Seismic and Geologic Siting Criteria for Nuclear Power Plants,” to 10 CFR Part 100, “Reactor Site Criteria.”

Operating condition categories. Categories of design limits for component and piping supports defined by NF-3113 of Section III of the ASME Code.

Plant conditions. Operating conditions of the plant categorized as normal, upset, emergency, and faulted plant conditions.

Safe-shutdown earthquake. Seismic event defined in Appendix A to 10 CFR Part 100.

Service limits. Stress limits for the design of component and piping supports, defined by Subsection NF of Section III of the ASME Boiler and Pressure Vessel Code.

Specified seismic events. Operating-basis earthquake and safe-shutdown earthquake, defined above.

System mechanical loadings. The static and dynamic loadings developed by the system operating parameters—including deadweight, pressure, and other external loadings—and effects resulting from constraints of free-end movements, but excluding effects resulting from thermal and peak stresses generated within the component support.

Ultimate tensile strength. Material property based on the engineering stress-strain relationship.

Upset plant conditions. Those deviations from the normal plant condition that have a high probability of occurrence.

Harmonization with International Standards

ASME is the leading international developer of codes and standards associated with the art, science, and practice of mechanical engineering. Since the first issuance in 1914 of the Boiler & Pressure Vessel Code, ASME has maintained a commitment to enhance public safety and technological advancement. Pertinent to this regulatory guide, Subsection NF of the ASME Boiler and Pressure Vessel Code, Section III, “Rules for Construction of Nuclear Power Plant Components,” contains requirements for the material, design, fabrication, and examination of supports which are intended to conform to the requirements for Classes 1,2,3 and MC construction. This regulatory guide incorporates similar design and preoperational testing guidelines and it is consistent with the basics safety principles provided in Subsection NF of Section III of the BPVC.

Documents Discussed in Staff Regulatory Guidance

This regulatory guide endorses the use of one or more codes or standards developed by external organizations, and other third party guidance documents. These codes, standards and third party guidance

documents may contain references to other codes, standards or third party guidance documents (“secondary references”). If a secondary reference has itself been incorporated by reference into NRC regulations as a requirement, then licensees and applicants must comply with that standard as set forth in the regulation. If the secondary reference has been endorsed in a regulatory guide as an acceptable approach for meeting an NRC requirement, then the standard constitutes a method acceptable to the NRC staff for meeting that regulatory requirement as described in the specific regulatory guide. If the secondary reference has neither been incorporated by reference into NRC regulations nor endorsed in a regulatory guide, then the secondary reference is neither a legally binding requirement nor a “generic” NRC approval as an acceptable approach for meeting an NRC requirement. However, licensees and applicants may consider and use the information in the secondary reference, if appropriately justified and consistent with current regulatory practice, consistent with applicable NRC requirements such as 10 CFR 50.59, “Changes, Tests, and Experiments.”

C. STAFF REGULATORY GUIDANCE

The construction of ASME Code² Class 1 plate-and-shell-type component and piping supports—except snubbers, which this guide does not address—should follow the rules of Subsection NF of Section III of the Code, as supplemented by the following stipulations:³

1. The classification of component and piping supports should, as a minimum, be the same as that of the supported components and piping.
2. The critical buckling strength should always constrain the service limits for component and piping supports designed by linear elastic analysis. The calculation of critical buckling strength should use materials at temperature properties. Critical buckling stresses for service level A, B, C, and D limits should be maintained in accordance with paragraphs NF-3522, NF-3622 and F-1332.5 of Section III for loadings combined according to Regulatory Position 3 of this guide. Service limits related to critical buckling strength should not increase unless the ASME Code specifically allows such an increase. Service limits related to critical buckling strength should not increase unless the ASME Code specifically allows such an increase.
3. For component and piping supports subjected to the combined loadings of (1) the vibratory motion of the operating-basis earthquake and (2) system mechanical loadings⁴ associated with either the ASME Code design condition or normal or upset plant conditions, the design approach should be as follows:^{5,6}

² ASME Boiler and Pressure Vessel Code, Section III, Division I, 2007 Edition through the 2008 Addenda.

³ If the function of a component or piping support is not required during a plant condition, satisfaction of the design limits of the support for that plant condition is not needed, provided excessive deflections or failure of the support will not result in the loss of function of any other safety-related system.

⁴ System mechanical loadings include all non-self-limiting loadings and the effects resulting from constraints of free-end displacements, but not the effects resulting from thermal or peak stresses generated within the component or piping support.

⁵ Because component and piping supports are deformation-sensitive in the performance of their service requirements, satisfying these limits does not ensure the fulfillment of their functional requirements. Any deformation limits specified by the design specification may be controlling and should be satisfied.

⁶ Because the design of component and piping supports is an integral part of the design of the system and the component and piping, the designer should ensure that methods used for the analysis of the system, component and piping, and support are compatible. The designer of component and piping supports should consider large deformations in the system or components and piping.

- a. Supports designed by using the linear elastic analysis method should not exceed (1) the service limits of paragraphs NF-3522 and NF-3622 for design loadings and level A and B service limits and (2) the constraints discussed in Regulatory Position 2 of this guide.
 - b. Supports designed by the load-rating method should not exceed the load rating for level A or level B limits of NF-3280 of Section III.
 - c. Supports designed by the experimental stress analysis method should not exceed the test collapse load determined by II-1430 of Section III divided by 1.7.
4. The design of component and piping supports subjected to the system mechanical loadings⁵ associated with the emergency plant condition should adhere to the following design limits, except when the normal function of the supported system is to prevent or mitigate the consequences of events associated with the emergency plant condition (in which case, Regulatory Position 6 then applies):⁶
- a. Supports designed by the linear elastic analysis method should not exceed the service limits of NF-3522 and NF-3622 of Section III and Regulatory Position 2.
 - b. Supports designed by the load-rating method should not exceed the load rating for level C limits of NF-3280 of Section III.
 - c. Supports designed by the experimental stress analysis method should not exceed the test collapse load determined by II-1430 of Section III and divided by 1.3.
5. The design of component and piping supports subjected to the combined loadings of (1) the vibratory motion of the safe-shutdown earthquake, (2) the system mechanical loadings⁵ associated with the normal plant condition, and (3) the dynamic system loadings associated with the faulted plant condition should adhere to the following design limits, except when the normal function of the supported system is to prevent or mitigate the consequences of events associated with the faulted plant condition (in which case, Regulatory Position 6 then applies):⁶
- a. Supports designed by the linear elastic analysis method should not exceed the service limits of F-1332 of Section III.
 - b. Supports designed by the load-rating method should not exceed the value of $TL \times 0.7 S_u/S_u^*$, where TL and S_u^* are defined according to F-1332.7 of Section III and S_u is the ultimate tensile strength of the material at service temperature.
 - c. Supports designed by the experimental stress analysis method should not exceed the test collapse load determined by II-1430.
 - d. If plastic methods are used for the design of supports, the combined loadings of Regulatory Position 5 should include loads such as constraints of free-end displacements. The design should not exceed the service limits of F-1340 of Section III.
6. The design of component and piping supports in systems for which the normal function is to prevent or mitigate the consequences of events associated with an emergency or faulted plant condition should adhere to the limits described in Regulatory Position 3 or other justifiable limits such as the level C or level D service limits provided by the ASME Code. The design specification should define these limits so that the function of the supported system will be

maintained when the supports are subjected to the loading combinations described in Regulatory Positions 4 and 5.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees⁷ may use this guide and to provide information regarding the NRC's plans for using this regulatory guide. In addition, it describes how the NRC staff complies with 10 CFR 50.109, "Backfitting" and any applicable finality provisions in 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

Use by Applicants and Licensees

Applicants and licensees may voluntarily⁸ use the guidance in this document to demonstrate compliance with the underlying NRC regulations. Methods or solutions that differ from those described in this regulatory guide may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations. Current licensees may continue to use guidance the NRC found acceptable for complying with the identified regulations as long as their current licensing basis remains unchanged.

Licensees may use the information in this regulatory guide for actions that do not require NRC review and approval such as changes to a facility design under 10 CFR 50.59, "Changes, Tests, and Experiments." Licensees may use the information in this regulatory guide or applicable parts to resolve regulatory or inspection issues.

Use by NRC Staff

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this regulatory guide. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this regulatory guide, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this regulatory guide to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action that would require the use of this regulatory guide. Examples of such unplanned NRC regulatory actions include issuance of an order requiring the use of the regulatory guide, requests for information under 10 CFR 50.54(f) as to whether a licensee intends to commit to use of this regulatory guide, generic communication, or promulgation of a rule requiring the use of this regulatory guide without further backfit consideration.

During regulatory discussions on plant specific operational issues, the staff may discuss with licensees various actions consistent with staff positions in this regulatory guide, as one acceptable means of meeting the underlying NRC regulatory requirement. Such discussions would not ordinarily be considered backfitting even if prior versions of this regulatory guide are part of the licensing basis of the facility. However, unless this regulatory guide is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this regulatory guide constitutes a violation.

⁷ In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52; the term "applicants" refers to applicants for licenses and permits for (or relating to) nuclear power plants under 10 CFR Parts 50 and 52 and applicants for standard design approvals and standard design certifications under 10 CFR Part 52.

⁸ In this section, "voluntary" and "voluntarily" mean that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this new or revised regulatory guide and (2) the specific subject matter of this regulatory guide is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the guidance in this regulatory guide or provide an equivalent alternative process that demonstrates compliance with the underlying NRC regulatory requirements. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

Additionally, an existing applicant may be required to comply to new rules, orders, or guidance if 10 CFR 50.109(a)(3) applies.

If a licensee believes that the NRC is either using this regulatory guide or requesting or requiring the licensee to implement the methods or processes in this regulatory guide in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfit appeal with the NRC in accordance with the guidance in NUREG-1409, "Backfitting Guidelines," (Ref. 4) and NRC Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection" (Ref. 5).

REFERENCES⁹

1. American Society of Mechanical Engineers (ASME), Section III, “Rules for Construction of Nuclear Power Plant Components,” ASME Boiler and Pressure Vessel Code, American Society of Mechanical Engineers, New York, NY.¹⁰
2. U.S. Code of Federal Regulations (CFR), *Title 10, Energy*, Part 50, “Domestic Licensing of Production and Utilization Facilities.”
3. U.S. Code of Federal Regulations (CFR), *Title 10, Energy*, Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants.”
4. U.S. Nuclear Regulatory Commission (NRC), NUREG-1409, “Backfitting Guidelines,” NRC, Washington, DC.
5. NRC, Management Directive 8.4, “Management of Facility-specific Backfitting and Information Collection,” NRC, Washington, DC.

⁹ Publicly available NRC published documents are available electronically through the NRC Library on the NRC’s public Web site at: <http://www.nrc.gov/reading-rm/doc-collections/>. The documents can also be viewed on-line or printed for a fee in the NRC’s Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or 800-397-4209; fax 301-415-3548; and e-mail pdr.resource@nrc.gov.

¹⁰ Copies of American Society of Mechanical Engineers (ASME) standards may be purchased from ASME, Two Park Avenue, New York, NY 10016-5990; Telephone 800-843-2763. Purchase information is available through the ASME Web site store at <http://www.asme.org/Codes/Publications/>.