U.S. NUCLEAR REGULATORY COMMISSION

March 2007
Revision 2

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.130

(Draft was issued as DG-1169, dated October 2006)

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

A. INTRODUCTION

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 Part 50) (Ref. 1) 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 guide delineates acceptable 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 Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Ref. 2). This guide applies to light-water-cooled reactors.

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

B. DISCUSSION

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 versions[1] of ASME Code Cases N-71 and N-249 give 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.

---

[1] Regulatory Guide 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III" (Ref. 3) 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.

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. 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 that 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.

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 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 the 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 for which the 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 (ECCS) 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

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

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.

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.

*Upset Plant Condition*s. Those deviations from the normal plant condition that have a high probability of occurrence.

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.

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.

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.

Operating-Basis Earthquake (OBE). Seismic event defined in Appendix A, “Seismic and Geologic Siting Criteria for Nuclear Power Plants,” to 10 CFR Part 100, “Reactor Site Criteria.”

Safe-Shutdown Earthquake (SSE). Seismic event defined in Appendix A to 10 CFR Part 100.

Specified Seismic Events. Operating-Basis Earthquake (OBE) and Safe-Shutdown Earthquake (SSE), 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.

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

C. REGULATORY POSITION

The construction of ASME Code 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:[2]

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 limit the service limits for component and piping supports designed by linear elastic analysis. The calculation of critical buckling strength should use material at temperature properties. Critical buckling stresses for service level A, B, C, and D limits should be maintained in accordance with NF-3522, NF-3622 and F-1332.5 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.

3. For component and piping supports subjected to the combined loadings of (1) the vibratory motion of the OBE and (2) system mechanical loadings[3] associated with either the ASME Code design condition or normal or upset plant conditions, the design approach should be as follows:[4, 5]

   a. Supports designed by the linear elastic analysis method should not exceed (1) the service limits of NF-3522 and NF-3622 for design loadings and level A and B service limits and (2) 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.

---

2 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.

3 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.

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

5 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 make sure 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.

4. The design of component and piping supports subjected to the system mechanical loadings[4] 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 (Regulatory Position 6 then applies):[5,6]

   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 SSE, (2) the system mechanical loadings[4] 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 (Regulatory Position 6 then applies):[5,6]

   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 x 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 to licensees regarding the NRC staff's plans for using this regulatory guide. No backfitting is intended or approved in connection with the issuance of this guide.

Except in those cases in which a licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the NRC staff will use the methods described in this guide to evaluate (1) submittals in connection with applications for construction permits, standard plant design certifications, operating licenses, early site permits, and combined licenses; and (2) submittals from operating reactor licensees who voluntarily propose to initiate system modifications that have a clear nexus with the subject for which guidance is provided herein.

REGULATORY ANALYSIS / BACKFIT ANALYSIS

The regulatory analysis and backfit analysis for this regulatory guide are available in Draft Regulatory Guide DG-1169, "Service Limits and Loading Combinations for Class 1 Plate-and-Shell-Type Component Supports" (Ref. 4). The NRC issued DG-1169 in October 2006 to solicit public comment on the draft of this Revision 2 of Regulatory Guide 1.130.

REFERENCES

1. *U.S. Code of Federal Regulations,* Title 10, *Energy,* Part 50, "Domestic Licensing of Production and Utilization Facilities."[6]

2. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Power Plant Components," Division I, 2001 Edition through the 2003 Addenda, American Society of Mechanical Engineers, New York, NY, 1992.[7]

3. Regulatory Guide 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III," U.S. Nuclear Regulatory Commission, Washington, DC.[8]

4. Draft Regulatory Guide DG-1169, "Service Limits and Loading Combinations for Class 1 Plate-and-Shell-Type Component Supports," U.S. Nuclear Regulatory Commission, Washington, DC.[9]

---

[6] All NRC regulations listed herein are available electronically through the Public Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/cfr/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; email PDR@nrc.gov.

[7] Copies may be purchased from the American Society of Mechanical Engineers, Three Park Avenue, NewYork, NY 10016-5990; phone (212) 591-8500; fax (212) 591-8501; www.asme.org.

[8] All regulatory guides listed herein were published by the U.S. Nuclear Regulatory Commission. Where an accession number is identified, the specified regulatory guide is available electronically through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. All other regulatory guides are available electronically through the Public Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/. Single copies of regulatory guides may also be obtained free of charge by writing the Reproduction and Distribution Services Section, ADM, USNRC, Washington, DC 20555-0001, or by fax to (301) 415-2289, or by email to DISTRIBUTION@nrc.gov. Active guides may also be purchased from the National Technical Information Service (NTIS) on a standing order basis. Details on this service may be obtained by contacting NTIS at 5285 Port Royal Road, Springfield, Virginia 22161, online at http://www.ntis.gov, by telephone at (800) 553-NTIS (6847) or (703) 605-6000, or by fax to (703) 605-6900. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville, Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555-0001. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4209, by fax at (301) 415-3548, and by email to PDR@nrc.gov.

[9] Draft Regulatory Guide DG-1169 is available electronically under Accession #ML063000484 in the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555-0001. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4209, by fax at (301) 415-3548, and by email to PDR@nrc.gov.