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DRAFT REGULATORY GUIDE

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(Proposed Revision 2 of Regulatory Guide 1.130, dated October 1978)

SERVICE LIMITS AND LOADING COMBINATIONS FOR CLASS I PLATE-AND-SHELL-TYPE COMPONENT 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) 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 could jeopardize the ability of the supported component 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 supports, as defined in Subsection NF of Section III of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code.[1] This guide applies to light-water-cooled reactors.

[1] ASME Boiler and Pressure Vessel Code, Section III, Division I, 2001 Edition through the 2003 Addenda. Copies may be obtained from the American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990; phone (212) 591-8500; fax (212) 591-8501; http://www.asme.org/.

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 regulatory guides is not required. The NRC issues regulatory guides in draft form to solicit public comment and involve the public in developing the agency's regulatory positions. Draft regulatory guides have not received complete staff review and, therefore, they do not represent official NRC staff positions.

This regulatory guide contains information collections that are covered by the requirements of 10 CFR Part 50 which 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 collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Background

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

To provide a consistent level of safety, the ASME Code classification for component supports should, as a minimum, be the same as that of the supported components. This guide delineates levels of service limits and loading combinations, as well as supplementary criteria, for Class 1 plate-and-shell-type component 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 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 component supports.

Component 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 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.

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 in the latest accepted versions[2] 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 supports. These tables list values at various temperatures for the design stress intensity S_m, minimum yield strength S_y, and 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 of the critical buckling strength of the component support at temperature. Similarly, F-1331.5(a) limits the increase for Service Level D to two-thirds of the critical buckling strength of the component support at temperature. Because buckling prevents "shakedown" in a load-bearing member, it should 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 these material properties both change with temperature, calculation of the critical buckling stresses should use the values of E and S_y of the component 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.

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.

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.

Large Deformations

The design of component supports is an integral part of the design of a system and its components. A complete and consistent design is possible only when the interaction between the system, component, and component support is properly considered. When all three 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.

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2 Regulatory Guide 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III," provides guidance for the acceptability of ASME Code, Section III code cases and their revisions, including ASME 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.

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 three elements. The selection of these acceptable combinations assumes that component 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).

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.

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 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 (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.

Deformation Limits

Because component 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. However, if a particular plant condition does not require the function of a component 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.

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 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 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 component 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 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 below:[3]

1. The classification of component supports should, as a minimum, be the same as that of the supported components.

2. The critical buckling strength should always limit the service limits for component 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 (below). Service limits related to critical buckling strength should not increase unless the ASME Code specifically allows such an increase.

3. For component supports subjected to the combined loadings of (1) the vibratory motion of the OBE and (2) system mechanical loadings[4] associated with either the ASME Code design condition or normal or upset plant conditions, the design approach should be as follows:[5, 6]

    a. Component 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 (above).

    b. Component supports designed by the load-rating method should not exceed the load rating for Level A or B limits of NF-3280 of Section III.

    c. Component 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 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]

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[3] If the function of a component 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 support.

[5] Because component 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.

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

a. Component 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. Component supports designed by the load-rating method should not exceed the load rating for level C limits of NF-3280 of Section III.

c. Component 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 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. Component supports designed by the linear-elastic-analysis method should not exceed the service limits of F-1332 of Section III.

b. Component 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. Component 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 component 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 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 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 applicants and licensees regarding the NRC staff's plans for using this draft regulatory guide. No backfitting is intended or approved in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. Except in those cases in which an applicant or licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the methods to be described in the active guide will reflect public comments and will be used in evaluating (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 if there is a clear nexus between the proposed modifications and the subject for which guidance is provided herein.

REGULATORY ANALYSIS

1. Statement of the Problem

The NRC issued Revision 1 of Regulatory Guide 1.130, "Service Limits and Loading Combinations for Class 1 Plate-and-Shell-Type Component Supports," in October 1978 to document service limits and load combinations for the design of Class 1 plate-and-shell-type component supports in accordance with the requirements of Section III, Division I, Subsection NF of the ASME Boiler and Pressure Vessel Code, 1977 Edition, including the 1977 Winter Addenda.

The NRC staff updated draft Revision 2 of the regulatory guide to incorporate revisions documented in the 2001 Edition through the 2003 Addenda of the ASME Code, as permitted by 10 CFR 50.55a(b)(1), revised on January 1, 2006. The staff also modified the draft revision of the regulatory guide to delete guidance supplanted by current Code requirements.

2. Objective

This regulatory action updates the guidance regarding the design of Class 1 plate-and-shell-type component supports. The revised regulatory guide will continue to provide guidance to applicants and licensees on the acceptable levels of service limits and appropriate load combinations for the design of Class 1 plate-and-shell-type component supports. Use of the regulatory guide as an adjunct to the ASME Code requirements will give applicants and licensees additional assurance that the design of Class 1 plate-and-shell-type component supports is being implemented conservatively.

3. Alternative Approaches

The NRC staff considered the following alternative approaches to the problem of outdated guidance regarding the design of Class 1 plate-and-shell-type component supports:

(1) Do not revise Regulatory Guide 1.130.
(2) Update Regulatory Guide 1.130.

3.1 <u>Alternative 1: Do Not Revise Regulatory Guide 1.130</u>

Under this alternative, the NRC would not revise this guidance, and licensees would continue to use the original version of this regulatory guide. This alternative is considered the baseline or "no action" alternative and, as such, involves no value/impact considerations.

3.2 <u>Alternative 2: Update Regulatory Guide 1.130</u>

Under this alternative, the NRC would update Regulatory Guide 1.130 to incorporate revisions documented in the newer edition and addenda of the ASME Code and to delete guidance supplanted by current Code requirements.

The benefit of this action is to provide additional assurance to applicants and licensees that the design of Class 1 plate-and-shell-type component supports is being implemented conservatively.

The costs to the NRC would be the one-time, relatively small expense of issuing the revised regulatory guide, and applicants and licensees would incur little or no cost.

4. Conclusion

On the basis of this regulatory analysis, the staff recommends that the NRC revise Regulatory Guide 1.130. The staff concludes that the proposed action will provide additional assurance to applicants and licensees that the design of Class 1 plate-and-shell-type component supports is being implemented conservatively.

BACKFIT ANALYSIS

This draft revision to the regulatory guide provides licensees and applicants with updated guidance that the NRC staff considers acceptable for the design of Class 1 plate-and-shell-type component supports. The application of this regulatory guide is voluntary. Licensees may continue to use the original version of this regulatory guide if they so choose. No backfit, as defined in 10 CFR 50.109, "Backfitting," is either intended or implied.