U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

3.9.1 SPECIAL TOPICS FOR MECHANICAL COMPONENTS

REVIEW RESPONSIBILITIES

Primary - Mechanical Engineering Branch (MEB)

Secondary - None

I. AREAS OF REVIEW

The MEB reviews information in the SAR concerning methods of analysis for seismic Category I components and supports, including both those designated as Code* Class 1, 2, 3, or CS and those not covered by the Code. Certain aspects of dynamic system analysis methods are discussed in Standard Review Plan Section 3.9.2 as well as this SRP section. Information is also reviewed concerning design transients for Code Class 1 and CS components and supports. The following specific subjects are reviewed under this SRP section:

1. Transients which are used in the design and fatigue analyses of all Code Class 1 and CS components, and supports and reactor internals. The Reactor Systems Branch confirms on request the acceptability of the listed transients and the number of cycles and events expected over the service lifetime of the plant. The Structural Engineering Branch confirms the seismic cyclic ground input loading as described in SRP Section 3.7.3. The method used to determine the seismic cyclic loading used for fatigue analysis of appropriate components and supports will be reviewed.

2. Description and verification of all computer programs which will be used in analyses of seismic Category I Code and non-Code items listed in this SRP section.

3. Description of any experimental stress analysis programs which will be used in lieu of theoretical stress analyses.

*American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III (hereafter "the Code").

4. Description of the analysis methods which will be used if the applicant elects to use elastic-plastic stress analysis methods in the design of any of the above-noted components.

II. ACCEPTANCE CRITERIA

MEB acceptance criteria is based on meeting the relevant requirements of the following regulations:

1. General Design Criterion 1 as it relates to components important to safety being designed, fabricated, erected, constructed, tested and inspected in accordance with the requirements of applicable codes and standards commensurate with the importance of the safety-function to be performed.

2. General Design Criterion 2 as it relates to safety-related mechanical components of systems being designed to withstand seismic events without loss of capability to perform their safety function.

3. General Design Criterion 14 as it relates to the reactor coolant pressure boundary being designed so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

4. General Design Criterion 15 as it relates to the mechanical components of the reactor coolant system being designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences.

5. 10 CFR Part 50, Appendix B as it relates to design quality control.

6. 10 CFR Part 100, Appendix A as it relates to the suitability of the plant design bases for mechanical components established in consideration of site seismic characteristics.

Specific criteria necessary to meet the relevant requirements of the regulations listed above are as follows:

1. To meet the requirements of GDC 1, 2, 14, 15, and 10 CFR Part 100, Appendix A, the applicant shall provide a complete list of transients to be used in the design and fatigue analysis of all Code Class 1 and CS components, supports and reactor internals within the reactor coolant pressure boundary. The number of events for each transient and the number of load and stress cycles per event and for events in combination shall be included. All transients such as startup and shutdown operations, power level changes, emergency and recovery conditions, switching operations (i.e., startup or shutdown of one or more coolant loops), control system or other system malfunctions, component malfunctions, transients resulting from single operator errors, inservice hydrostatic tests, seismic events as determined from the criteria specified in Appendix A of 10 CFR Part 100, and design basis events, that are contained in the Code-required "Design Specifications" for the components of the reactor coolant pressure boundary shall be specified, including reactor internals and core support structures.

   The section of the applicant's SAR which pertains to transients will be acceptable if the transient conditions selected for equipment fatigue evaluation are based upon a conservative estimate of the magnitude and

frequency of the temperature and pressure conditions resulting from those transients. To a large extent the selection of these specific transient conditions is based upon engineering judgment and experience. Some guidance on the selection of these transients and combinations can be found in References 8 and 9. Transients and resulting loads and load combinations with appropriate specified design and service limits must provide a complete basis for design of the reactor coolant pressure boundary for all conditions and events expected over the service lifetime of the plant.

2. To meet the requirements of 10 CFR Part 50, Appendix B and GDC 1, a list of computer programs that will be used (preferably programs which are recognized and widely known) in dynamic and static analyses to determine the structural and functional integrity of seismic Category I Code and non-Code items, and the analyses to determine stresses shall be provided. For each program the following information shall be provided to demonstrate its applicability and validity:

   a. The author, source, dated version and facility.

   b. A description, and the extent and limitation of its application.

   c. The computer program solutions to a series of test problems which shall be demonstrated to be substantially similar to solutions obtained from any one of sources 1 through 4, and source 5:

      (1) hand calculations
      (2) analytical results published in the literature
      (3) acceptable experimental tests
      (4) by an MEB acceptable similar program
      (5) the benchmark problems prescribed in Reference 10.

      A summary comparison of the solution obtained by using sources 1 through 4 shall be provided, in either graphical or numerical form. For source 5, the complete computer printout of the input and the solution shall be submitted for every benchmark problem. These solutions may be referenced, and need not be resubmitted, in subsequent license application provided the information submitted under a. and b. remains unchanged.

3. To meet the requirements of GDC 1, 14, and 15, if experimental stress analysis methods are used in lieu of analytical methods, for any seismic Category I Code or non-Code items, the section of the SAR discussing the experimental stress analysis methods will be acceptable if the information provided meets the provisions of Appendix II of Reference 7, and as in the case of analytical methods, if the information provided is sufficiently detailed to show the validity of the design to meet the provisions of the Code-required "Design Specifications."

4. To meet the requirements of GDC 1, 14, and 15 when Service Level D limits are specified by the applicant for Code Class 1 and CS components, and for supports, reactor internals, and other non-Code items, the methods of analysis used to calculate the stresses and deformations shall conform to the methods outlined in Appendix F of Reference 7, subject to the conditions discussed in subsection III.4 below.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from the procedures described below, as may be appropriate for a particular case.

1. The list of transients, the number of events estimated for each transient presented in the applicant's SAR, and the method used to determine this number are compared to the same information on similar and previously licensed applications and to the acceptance criteria outlined in subsection II above. Any deviations from previous accepted practice are noted and the applicant is required to justify these deviations. For Code Class 1 and CS components and supports the MEB verifies that for each transient loading condition or combination an acceptable Code service limit has been specified, i.e., Design, Level A, Level B, Level C, or Level D as specified in Reference 7.

   Any deviations that have not been justified to the satisfaction of the staff are identified and the finding is transmitted to the applicant with a request that, unless conformance with the MEB acceptance criteria is agreed upon, additional technical justification be submitted.

2. The information pertaining to computer programs which is presented in the applicant's SAR is reviewed as follows:

   a. The list of programs is evaluated to determine that the applicant has adequately described each program with respect to the type of analysis that is performed and the specific components to which the program is applied.

   b. The submitted computer solutions to the test problems required in subsection II.2 of this SRP section are reviewed and compared to the test solutions. Satisfactory agreement of computer and test solutions, usually within a $\pm$5% error band, provides verification of the quality and adequacy of the computer programs to perform the functions for which they were designed.

   Any deviations that have not been justified to the satisfaction of the staff are identified and the finding is transmitted to the applicant with a request that, unless conformance with the MEB acceptance criteria is agreed upon, additional technical justification be submitted.

3. If the applicant elects to use experimental stress analysis techniques in lieu of theoretical stress analyses, sufficient information must be presented in the SAR to demonstrate that the requirements of Appendix II to Reference 7 as they apply to the conditions set forth in the "Design Specifications" have been met.

4. If the applicant employs an elastic or an elastic-plastic method of analysis to evaluate the design of safety-related Code or non-Code items for which Service Level D limits have been specified (NB-3225 and Appendix F of Reference 7), the review covers the following points:

   a. The applicant must demonstrate that the stress-strain relationship for component materials that will be used in the analysis is valid. The ultimate strength values at service temperature must be justified.

b. The analytical procedures to be used in the analysis are reviewed to determine the validity of the analysis. If a computer program is used, the applicable requirements of subsection II.2 above shall be met.

c. If elastic system analysis is used, its application may require detailed review and justification if applied to the analysis of systems which contain active components with close tolerances, or systems in which the sequence of load application could significantly affect the actual stress distribution.

d. If elastic, elastic-plastic or limit analysis methods are used for components in conjunction with elastic or elastic-plastic system analyses, the basis upon which these procedures are used are reviewed. The applicant shall provide assurance that the calculated item or item support deformations and displacements do not violate the corresponding limits and assumptions on which the methods used for the system analysis are based.

Any deviations that have not been justified to the satisfaction of the staff are identified and the finding is transmitted to the applicant with a request that, unless conformance with the MEB acceptance criteria is agreed upon, additional technical justification be submitted.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided in accordance with this SRP section, and that his evaluation supports conclusions of the following type, to be included in the staff's safety evaluation report:

The staff concludes that the design transients and resulting loads and load combinations with appropriate specified design and service limits for mechanical components is acceptable and meets the relevant requirements of General Design Criteria 1, 2, 14, 15, 10 CFR Part 50, Appendix B, and 10 CFR Part 100, Appendix A. This conclusion is based on the following:

1. The applicant has met the relevant requirements of General Design Criteria 14 and 15 by demonstrating that the design transients and resulting loads and load combinations with appropriate specified design and service limits which the applicant has used for designing Code Class 1 and CS components and supports, and reactor internals provide a complete basis for design of the reactor coolant pressure boundary for all conditions and events expected over the service lifetime of the plant.

2. The applicant has met the relevant requirements of General Design Criteria 2 and 10 CFR Part 100, Appendix A by including seismic events in design transients which serve as design basis to withstand the effects of natural phenomena.

3. The applicant has met the relevant requirements of 10 CFR Part 50, Appendix B, and General Design Criteria 1 by having submitted information that demonstrates the applicability and validity of the design methods and computer programs used for the design and analysis of seismic Category I Code Class 1, 2, 3, and CS structures, and non-Code structures within the present state-of-the-art limits and by having design control measures which are acceptable to assure the quality of the computer programs.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants regarding the NRC staff's plan for using this SRP section.

Except in those cases in which the applicant proposes acceptable alternative methods for complying with specified portions of the Commission's regulations, the methods described here will be used by the staff in its evaluation of comformance with Commission regulations.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, Criterion 1, "Quality Standards and Reports."

2. 10 CFR Part 50, Appendix A, Criterion 2, "Design Bases for Protection Against National Phenomena."

3. 10 CFR Part 50, Appendix A, Criterion 14, "Reactor Coolant Pressure Boundary."

4. 10 CFR Part 50, Appendix A, Criterion 15, "Reactor Coolant System Design."

5. 10 CFR Part 50, Appendix B, "Quality Assurance Requirements for Nuclear Power Plants and Fuel Reprocessing Plants."

6. 10 CFR Part 100, Appendix A, "Reactor Site Criterion."

7. ASME Boiler and Pressure Vessel Code, Section III, Divison I, "Nuclear Power Plant Components," American Society of Mechanical Engineers.

8. Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Reactor Power Plants."

9. Standard Review Plan Section 3.9.3, "ASME Code Class 1, 2, 3 Components, Component Supports, and Core Support Structures."

10. Report NUREG/CR-1677, "Piping Benchmark Problems."