U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 3.9.1 SPECIAL TOPICS FOR MECHANICAL COMPONENTS

REVIEW RESPONSIBILITIES

Primary - Mechanical Engineering Branch (MEB)

Secondary - Reactor Systems Branch (RSB)
Structural Engineering Branch (SEB)

I. AREAS OF REVIEW

Information concerning design transients and methods of analysis for seismic Category I components, including both those designated as Class 1, 2, 3, or CS under the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III (hereafter "the Code"), and component supports, reactor internals, and other components not covered by the Code, is given in the applicant's safety analysis report (SAR) and is reviewed by the MEB. Certain aspects of dynamic system analysis methods are discussed in Standard Review Plan 3.9.2 as well as in this plan. The following specific subjects are reviewed under this plan:

1. Transients which are used in the design and fatigue analyses of all Code Class 1 and CS components, and of component supports and reactor internals. The Reactor Systems Branch confirms the acceptability of the listed design transients and the number of cycles and events expected over the service lifetime of the plant. The Structural Engineering Branch confirms the number of seismic cyclic loadings acceptable for design. (For design of other non-Code components, see Standard Review Plan 3.9.3.)

2. Descriptions of all computer programs which will be used in analyses of Code and non-Code items listed in this plan.

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

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

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review are as follows:

1. 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, and of component supports and reactor internals within the reactor coolant pressure boundary. The number of events for each transient shall be included along with assurance that the number of load and stress cycles per event is properly taken into account. All design 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, etc., that are contained in the Code-required "Design Specifications" for the components of the reactor coolant pressure boundary shall be specified. All transients or combinations of transients shall be categorized with respect to the plant operating conditions identified as "normal," "upset," "emergency," "faulted," or "testing" and defined in Reference 4.

   The section of the applicant's SAR which pertains to design 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 judgement and experience. Some guidance on the selection of these transients can be found in Reference 5. The design transients, plant and component conditions, and loading combinations 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 to satisfy, in part, the requirements of References 1 and 2.

2. A list of computer programs that will be used in dynamic and static analyses to determine the structural and function integrity of seismic Category I Code and non-Code items and the analyses to determine stresses shall be provided, including a brief description of each program and the extent of its application. The design control measures, as required by Appendix B of 10 CFR Part 50, that will be employed to demonstrate the applicability and validity of these computer programs should meet one of the following criteria:
   a. The computer program is recognized and widely used, with a sufficient history of successful use to justify its applicability and validity without further demonstration by the applicant. The dated program version that will be used, the software or operating system, and the hardware configuration must be specified to be accepted by virtue of its history of use.

b. The computer program solutions to a series of test problems with accepted results have been demonstrated to be substantially identical to those obtained by a similar program which meets the criteria of (a) above. The test problems shall be demonstrated to be similar to or with the range of applicability for the problems analyzed by the computer program to justify acceptance of the program.

c. The program solutions to a series of test problems are substantially identical to those obtained by hand calculations or from accepted experimental tests or analytical results published in technical literature. The test problems shall be demonstrated to be similar to the problems analyzed to justify acceptance of the program.

A summary comparison of the results obtained from the use of each computer program under options (b) or (c) above with either the results derived from a similar program meeting option (a), or a previously approved computer program, or results from the test problems of option (c) shall be provided. Include typical static and dynamic response loading, stress, etc., comparisons, preferably in graphical form.

3. 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 4, 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. When inelastic stress or deformation design limits are specified by the applicant for Code Class 1 and CS components, and for component supports. reactor internals, and other non-Code items, the methods of analysis used to calculate the stresses and deformations resulting from faulted condition loadings shall conform to the methods outlined in Appendix F of Reference 4, subject to deformation constraints discussed in III.4 below. It is acceptable to apply similar limits to Code Class 2 and 3 components provided the analytical methods, applicable criteria, and fabrication procedures of Code Class 1 components are used. Other applicable limits permitted by the Code are acceptable.

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 and the number of events estimated for each transient presented in the applicant's SAR is compared to the same information on similar and previously licensed applications and to the acceptance criteria outlined in II above. Any deviations from previous accepted practice are noted and the applicant is required to justify these deviations. The MEB verifies that each design

transient has been properly categorized with respect to the component operating conditions of design, i.e., "normal," "upset," "emergency," "faulted" and "testing" as defined in Reference 4.

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 design control measures, which are required by 10 CFR Part 50, Appendix B, are reviewed for each program. The procedures outlined in II.2.a, b, or c of this plan must be met for each program. Verification by the applicant that he has met the requirements of at least one of the above paragraphs is acceptable.
   c. The summary comparison of the results obtained from the use of each program which is not recognized and widely used (See II.2 of this plan) with either the results derived from a similar recognized and widely used program, a previously approved computer program, or results from test problems is reviewed and evaluated. Numerical results so derived should compare favorably enough to provide confidence in the validity of the program.

   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 4, as they apply to the conditions set forth in the "Design Specifications" have been met.

4. If the applicant employs an inelastic method of analysis to evaluate the design of safety-related Code or non-Code items for the faulted plant condition (NB-3225 and Appendix F of Reference 4), 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 II.2 above shall be met.

c. If elastic, elastic-inelastic, or limit analysis methods are used for components in conjunction with elastic or inelastic 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. (For example, current small deformation methods of analysis typically tend to have acceptable effective strain limits in the range of 1/2 to 1-1/2 percent and large deformation methods 10 to 20 percent.)

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 review plan, and that his evaluation supports conclusions of the following type, to be included in the staff's safety evaluation report:

"The criteria used in the methods of analysis that the applicant has employed in the design of all seismic Category I ASME Code Class 1, 2, 3, and CS components, component supports, reactor internals, and other non-Code items are in conformance with established technical positions and criteria which are acceptable to the Regulatory staff.

"The use of these criteria in defining the applicable design transients, computer codes used in analyses, analytical methods, and experimental stress analysis methods provides assurance that the stresses, strains, and displacements calculated for the above-noted items are as accurate as the current state-of-the-art permits and are adequate for the design of these items."

V. REFERENCES

1. 10 CFR Part 50, Appendix A, Criterion 14, "Reactor Coolant Pressure Boundary."

2. 10 CFR Part 50, Appendix A, Criterion 15, "Reactor Coolant System Design."

3. 10 CFR Part 50, Appendix B, "Quality Assurance Requirements for Nuclear Power Plants and Fuel Reprocessing Plants."

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

5. Regulatory Guide 1.68, "Preoperational and Initial Startup Test Programs for Water-Cooled Reactors."

SRP 3.9.2