U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 4.5.1 CONTROL ROD SYSTEM STRUCTURAL MATERIALS

REVIEW RESPONSIBILITIES

Primary - Materials Engineering Branch (MTEB)

Secondary - Core Performance Branch (CPB)
Mechanical Engineering Branch (MEB)

I. AREAS OF REVIEW

General Design Criterion 26 requires that one of the reactivity control systems shall use control rods, preferably including a positive means for inserting the rods, and shall be capable of reliably controlling reactivity changes to assure that fuel design limits are not exceeded under conditions of normal operation, including anticipated operational occurrences. The areas listed below relating to materials considerations in the design of the control rod system are reviewed. The review areas are similar to those given in Standard Review Plan 5.2.3, "Reactor Coolant Pressure Boundary Materials." For the purpose of this plan, the control rod system extends only to the coupling interface with the reactivity control (poison) elements in the reactor vessel.

The mechanical aspects of the control rod system other than the reactivity control elements are reviewed by the Mechanical Engineering Branch in accordance with Standard Review Plan 3.9.4.

The mechanical design, thermal performance and chemical compatibility of the reactivity control elements are addressed by the Core Performance Branch in accordance with Standard Review Plan 4.2.

1. Mechanical Properties

The mechanical properties of the materials used in the control rod system are reviewed from the standpoint of adequate performance throughout the design life of the plant (or the component). The systems generally include control rods and control rod drives. Materials commonly used include austenitic stainless steels (which may be cold worked), nitrided or chromium-plated stainless steels, martensitic stainless steels, precipitation-hardening stainless steels such as 17-4 pH, and other special-purpose materials such as cobalt-base alloys (stellites), Inconel-750, Colmonoy-6, and Graphitar-14.

2. Austenitic Stainless Steel Components

The use of sensitized stainless steels should be controlled to prevent stress-corrosion cracking of the material during operation of the plant. Welding procedures should be controlled to reduce the probability of sensitization and microfissure formation. Cold-worked stainless steels should not have too high a yield stress, to minimize the probability of stress-corrosion cracking during operation of the plant.

3. Other Materials

Special requirements for the other materials include minimum tempering and aging temperatures for martensitic and precipitation-hardening stainless steels to prevent their deterioration by stress corrosion during operation of the plant. The compatibility of these materials with the reactor coolant is reviewed to assure that they will continue to perform satisfactorily throughout the design life of the component.

4. Cleaning and Cleanliness Control

Proper care should be taken in handling the materials and parts of the control rod system during fabrication, shipping, and on-site storage to assure that all cleaning solutions, processing compounds, degreasing agents, and other foreign materials are completely removed, and that all parts are dried and properly protected following any flushing treatment with water.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review listed in Section I of this plan are as follows:

1. Mechanical Properties

The mechanical properties of the materials selected for the control rod system must be equivalent to those given in Appendix I to Section III of the ASME Boiler and Pressure Vessel Code (hereafter "the Code"), or Part A of Section II of the Code, except that cold-worked austenitic stainless steels shall have a 0.2% offset yield strength no greater than 90,000 psi, to minimize the probability of stress corrosion cracking occurring in these systems.

2. Austenitic Stainless Steel Components

Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel," describes acceptable methods for preventing intergranular corrosion of stainless steel components. Furnace-sensitized material should not be allowed, and methods described in this guide should be followed for cleaning and protecting austenitic stainless steels from contamination during handling, storage, testing, and fabrication, and for determining the degree of sensitization that occurs during welding. Nitrided stainless steel components may be in the sensitized condition, as indicated in Regulatory Guide 1.44. Branch Technical Position - MTEB No. 5-1, "Interim Position on Regulatory Guide 1.31, 'Control of Stainless Steel Welding'," (Ref. 9) describes acceptable criteria for assuring the integrity of welds in stainless steel components of these systems.

3. Other Materials

All materials for use in this system must be selected for their compatibility with the reactor coolant, as described in Articles NB-2160 and NB-3120 of the Code. The minimum tempering temperature of martensitic and aging temperature of precipitation-hardening stainless steels should be specified to provide assurance that these materials will not deteriorate by stress-corrosion cracking in service. Acceptable minimum treatment temperatures include aging at 1100°F for Type 17-4 PH and 1050°F for Type 410 stainless.

4. Cleaning and Cleanliness Control

Onsite cleaning and cleanliness control should be in accordance with Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants," and ANSI N45.2.1-1973, "Cleaning of Fluid Systems and Associated Components For Nuclear Power Plants" (Ref. 5).

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from the procedures described below, as may be appropriate for a particular case. To ascertain that the acceptance criteria given in Section II are met, the reviewer examines the review areas listed in Section I for the required information, using the following procedures:

1. Mechanical Properties

The reviewer compares the mechanical properties of the materials proposed for the control rod system with Appendix I to Section III of the Code, or Part A of Section II of the Code. He verifies that cold-worked austenitic stainless steels used in fabrication of the reactivity control systems are in conformance with Section II.1, above.

2. Austenitic Stainless Steel Components

The methods of controlling sensitized stainless steel are examined by the reviewer and compared with the positions given in Regulatory Guide 1.44, especially with respect to cleaning and protection from contamination during handling and storage, verification of non-sensitization of the material, and qualification of welding procedures using ASTM A-262-70 (Ref. 3). If alternative methods of testing the qualification welds for degree of sensitization are proposed by the applicant, the reviewer determines if these are satisfactory, taking into account branch positions taken on previous applications and the degree of equivalence of the alternate methods. The reviewer may ask the applicant to justify the technical basis for any departures from the cited positions. Alternative tests that have been accepted by the branch include the use of ASTM A-262-70 as amended by Westinghouse Process Specification 84201 MW (Ref. 6), for qualifying welds and testing raw materials for nonsensitization, and the use of ASTM A-393 specifications (Ref. 4) for testing the qualification welds for degree of sensitization.

The methods of controlling and measuring the amount of delta ferrite in stainless steel weld deposits are examined by the reviewer and compared to the positions in Regulatory Guide 1.31, "Control of Stainless Steel Welding," especially with respect to the filler

metal acceptance procedures for delta ferrite content and the examination of production welds. If alternative positions are proposed by the applicant, the reviewer determines if these are satisfactory, taking into account branch positions taken on previous applications. The reviewer may ask the applicant to justify the technical basis for any departures from the acceptance criteria stated in Section II.2.

3. Other Materials

The reviewer examines the information provided in the applicant's safety analysis report (SAR) on the compatibility of the materials (other than austenitic stainless steels) to be used in contact with the reactor coolant. He determines that the materials are compatible with the service environment so that corrosion or stress corrosion of the component will not occur during the lifetime of the component.

The reviewer determines that minimum tempering temperatures of all martensitic stainless steels and minimum aging temperatures of precipitation-hardening stainless steels have been specified, and are in accordance with the acceptance criteria stated in Section II.3.

4. Cleaning and Cleanliness Control

The reviewer verifies that onsite cleaning and cleanliness control procedures are satisfactory and in accordance with Section II.4.

5. General

If the information contained in the SAR or the plant Technical Specifications does not comply with the appropriate acceptance criteria, or if the information provided is inadequate to establish such compliance, a request for additional information is prepared and transmitted. Such requests identify not only the necessary additional information, but also, the changes needed in the SAR or the Technical Specifications. Subsequent amendments received in response to these requests are reviewed for compliance with the acceptance criteria.

IV. EVALUATION FINDINGS

Wher the reviewer has verified that sufficient and acceptable information has been provided in accordance with the requirements of this review plan, conclusions of the following type are prepared, to be included in the staff's safety evaluation report:

"The mechanical properties of materials selected for the control rod system components exposed to the reactor coolant satisfy Appendix I of Section III of the ASME Code, or Part A of Section II of the Code, and with the staff position that the yield strength of cold-worked austenitic stainless steel should not exceed 90,000 psi.

"The controls imposed upon the austenitic stainless steel of the systems conform to the recommendations of Regulatory Guide 1.31, "Control of Stainless Steel Welding" and Regulatory Guide 1.44, "Control of the use of Sensitized Stainless Steel." Fabrication and heat treatment practices performed in accordance with these recommendations provide added assurance that stress-corrosion cracking will not occur during the design life of the component. The compatibility of all materials used in the control rod system

in contact with the reactor coolant satisfies the criteria for Articles NB-2160 and NB-3120 of Section III of the Code. Both martensitic and precipitation-hardening stainless steels have been given tempering or aging treatments in accordance with staff positions. Cleaning and cleanliness control are in accordance with ANSI Standard N45.2.1-1973, "Cleaning of Fluid Systems and Associated Components for Nuclear Power Plants," and Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plant."

"Conformance with the codes, standards, and Regulatory Guides indicated above, and with the staff positions on the allowable maximum yield strength of cold-worked austenitic stainless steel, the minimum tempering or aging temperatures of martensitic and precipitation-hardened stainless steels constitutes an acceptable basis for meeting in part the requirements of General Design Criterion 26."

V. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 26, "Reactivity Control System Redundancy and Capability."

2. ASME Boiler and Pressure Vessel Code, Section III, Articles NB-2160 and NB-3120, and Appendix I, and Section II, Part A, American Society of Mechanical Engineers.

3. ASTM A-262-70, Practice E, "Copper-Copper Sulfate-Sulfuric Acid Test for Detecting Intergranular Attack in Austenitic Stainless Steel," Annual Book of ASTM Standards, Part 3, American Society for Testing and Materials.

4. ASTM A-393-63, "Recommended Practice for Conducting Acidified Copper Sulfate Test for Intergranular Attack in Austenitic Stainless Steel," Annual Book of ASTM Standards, Part 3, American Society for Testing and Materials.

5. ANSI N45.2.1-1973, "Cleaning of Fluid Systems and Associated Components for Nuclear Power Plants," Draft 2, Revision 0, November 15, 1973, American National Standards Institute.

6. Process Specification 84201 MW, "Corrosion Testing of Wrought Austenitic Stainless Steel," Westinghouse Electric Corporation.

7. Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants."

8. Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel."

9. Branch Technical Position - MTEB No. 5-1, "Interim Position on Regulatory Guide 1.31, 'Control of Stainless Steel Welding'," appended to Standard Review Plan 5.2.3.

SRP 4.5.2