NUREG-0800
(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

# STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

## 5.3.1 REACTOR VESSEL MATERIALS

REVIEW RESPONSIBILITIES

Primary - Materials Engineering Branch (MTEB)

Secondary - None

### I. AREAS OF REVIEW

The following areas relating to reactor vessel materials are reviewed:

1. Material Specifications

   The material specifications used for the reactor vessel and applicable appurtenances, such as the shroud support, studs, control rod drive housings, vessel support skirt, stub tubes, and instrumentation housings, are reviewed and their adequacy for use in the construction of such components is assessed on the basis of the mechanical and physical properties of the materials, the effects of irradiation on these materials, their corrosion resistance, and their fabricability. Similarly, the specifications for austenitic steel and nonferrous metals specified for the above applications are reviewed with respect to mechanical properties, stress-corrosion resistance, and fabricability.

2. Special Processes Used for Manufacture and Fabrication of Components

   Information submitted by the applicant for any special process used in the manufacture of the product forms supplied and for their fabrication into the reactor vessel or any of its appurtenances is reviewed, and the capability of these processes to provide components with suitable mechanical and physical properties is assessed. The effects of such special processes on the stress-corrosion characteristics of the material, and any aspect of the process which could cause special requirements for nondestructive examinations, are reviewed.

3. Special Methods for Nondestructive Examination

   Nondestructive examination methods differing from those described in the ASME Boiler and Pressure Vessel Code (hereafter "the Code"), Section III, are reviewed. Attention is directed towards calibration methods, instrumentation, methods of application, sensitivity, reliability, and standards used.

4. Special Controls and Special Processes Used for Ferritic Steels and Austenitic Stainless Steels

Information on special controls and special processes for welding ferritic steels and austenitic stainless steels is reviewed, and their adequacy is assessed. The extent to which the controls and processes deviate from Code rules is reviewed. Information on welding of safe-ends during the fabrication of dissimilar metal joints is given particular attention and details of the methods, processes, and materials used are reviewed.

5. Fracture Toughness

Fracture toughness of the ferritic materials used for reactor vessels and appurtenances thereto is reviewed to ensure that such components will behave in a nonbrittle manner and that the probability of rapidly propagating fracture will be minimized under operating, maintenance, and testing conditions and during anticipated operational occurrences. The review includes the descriptions of the fracture toughness tests performed on all ferritic materials used for the reactor vessel and appurtenances thereto, and includes Charpy V-notch impact test specimens, dropweight test specimens, and any other test specimens included by the applicant.

The test procedures specified by the applicant are reviewed and their adequacy is confirmed.

The composition of ferritic materials employed for the reactor vessel is reviewed and the amount of residual elements such as copper and phosphorus is checked. The results of impact tests performed on base material, weld metal, and heat-affected zones are reviewed, and the scope of the testing is checked, particularly in the area of the reactor vessel beltline region, where radiation effects on the material are most significant.

Fracture toughness of the materials employed is characterized by its reference temperature, $RT_{NDT}$. This temperature is the higher value of the nil-ductility temperature (NDT) from the dropweight test, or the temperature that is 60°F below the temperature at which Charpy V-notch impact test data meet a specified toughness level. The information submitted is checked to ensure that the $RT_{NDT}$ of the materials is included with the data and test results for impact testing.

6. Material Surveillance

Reactor vessel material surveillance must be performed to monitor changes in the fracture toughness properties of ferritic materials in the reactor vessel beltline region of water-cooled power reactors, resulting from exposure to neutron irradiation and the thermal environment. Under the surveillance programs, fracture toughness test data are obtained from material specimens withdrawn periodically from the reactor vessel. These data will permit the determination of the conditions under which the vessel can be operated with adequate margins of safety against fracture throughout its service life.

7. Reactor Vessel Fasteners

The materials for the stud bolts, washers, and nuts, or other fasteners used to hold the reactor vessel head, are reviewed to determine their adequacy. Mechanical properties, including fracture toughness, are checked to ensure that all requirements are met. Lubricants or surface treatments used are reviewed to ensure that the studs will be resistant to stress-corrosion cracking under the environmental conditions during service and shutdowns. The adequacy of the destructive testing procedures used to ensure initial integrity is reviewed, along with the applicable acceptance criteria.

In addition, the MTEB will coordinate evaluations, of other branches, that interface with the overall review of the reactor vessel materials as follows:

The Chemical Engineering Branch (CMEB) determines the compatibility of the thermal insulation with the austenitic stainless steel of the reactor vessel appurtenances and determines the acceptability of any nonmetallic thermal insulation that is employed, as part of its secondary review responsibility for SRP Section 5.2.3.

The review for Quality Assurance is coordinated and performed by the Quality Assurance Branch (QAB) as part of its primary review responsibility for SRP Sections 17.1 and 17.2.

For those areas of review identified above as part of the review responsibility of other branches, the acceptance criteria necessary for the review and their method of application are contained in the referenced SRP section of the corresponding branch.

## II. ACCEPTANCE CRITERIA

MTEB acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. Section 50.55a, as it relates to quality standards for design, and determination and monitoring of fracture toughness;

2. General Design Criteria (GDC) 1 and 30, as they relate to quality standards for design, fabrication, erection, and testing of structures, systems and components;

3. General Design Criterion 4, as it relates to compatibility of components with environmental conditions;

4. General Design Criterion 14, as it relates to prevention of rapidly propagating fractures of the RCPB;

5. General Design Criterion 31, as it relates to material fracture toughness;

6. General Design Criterion 32, as it relates to the requirements for a materials surveillance program;

7. Appendix B, as it relates to onsite material cleaning control;

8. Appendix G, as it relates to materials testing and acceptance criteria for fracture toughness; and

9. Appendix H, as it relates to the determination and monitoring of fracture toughness.

Specific criteria necessary to meet the relevant requirements of 10 CFR Part 50, § 50.55a; GDC 1, 4, 14, 30, 31, and 32; and Appendices B, G, and H are as follows for each review described in subsection I of this SRP section:

1. <u>Material Specifications</u>

   The requirements of GDC 1 and 30 and § 50.55a regarding quality standards are met by compliance with the provisions of the ASME Code, Section III, for material specifications, as detailed below:

   a. Acceptable material specifications for the reactor vessel and its appurtenances are those listed in the Code, Section III, Appendix I, and are presented in detail in Code Section II, Parts A, B, and C. The materials must also meet the specifications requirements of 10 CFR Part 50, Appendix G.

   b. The acceptability of materials not specified in the Code are considered on an individual basis. Their suitability is evaluated on the basis of data submitted in accordance with the requirements of Code Section III, Appendix IV-1400 and 10 CFR Part 50, Appendix G. These data must include information on mechanical properties, weldability, and physical changes of the material.

2. <u>Special Processes Used for Manufacture and Fabrication of Components</u>

   The requirements of GDC 1 and 30 and § 50.55a regarding quality standards are met by compliance with the provisions of the ASME Code, Section III, for fabrication of components. The reactor vessel and its appurtenances are fabricated and installed in accordance with Code Section III, Paragraph NB-4100. The manufacturer or installer of such components is required to certify, by application of the appropriate Code Symbol and completion of an appropriate data report in accordance with Code Section III, Paragraph NA-8000, that the materials used comply with the requirements of NB-2000, and that the fabrication or installation comply with the requirements of NB-4000.

3. <u>Special Methods for Nondestructive Examination</u>

   The requirements of GDC 1 and 30 and § 50.55a regarding quality standards are met by compliance with the ASME Code, Section III, for fabrication nondestructive testing. The acceptance criteria for examination of the reactor vessel and its appurtenances by nondestructive examination are those specified in Code Section III, NB-5000, for normal methods of examination. When special techniques or procedures are developed, they must be equivalent or superior to the techniques described in Appendix IX-6000 of Code Section III, and must be proven so, by demonstration on the specific type of component part.

4. Special Controls and Special Processes Used for Ferritic Steels and Austenitic Stainless Steels

The acceptance criteria for special controls and processes in welding austenitic or ferritic steel components are based upon the following regulatory guides and ASME Code provisions necessary to satisfy the relevant requirements of GDC 1, 4, 14, and 30; Appendix B; and § 50.55a.

a. Only those welding processes capable of producing welds in accordance with the welding procedure qualification requirements of Code Sections III and IX may be used. Any process used shall be such that the records required by NB-4300 of Section III can be made, with the exception of stud welding, which is acceptable only for minor nonpressure attachments.

b. ASME Code Sections III and IX criteria for welding ferritic steel are supplemented by the regulatory positions in Regulatory Guides 1.50, "Control of Preheat Temperature for Welding Low-Alloy Steel," and 1.34, "Control of Electroslag Weld Properties."

c. The regulatory positions of Regulatory Guide 1.43, "Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components," provide the acceptance criteria to avoid underclad cracking of stainless steel clad ferritic components.

d. ASME Code Sections III and IX criteria for welding austenitic stainless steels are supplemented by the regulatory positions in Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal," and Regulatory Guide 1.34.

e. The regulatory positions of Regulatory Guides 1.44, "Control of the Use of Sensitized Stainless Steel," and 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants," provide the acceptance criteria to avoid sensitization and contamination of stainless steel.

The referenced regulatory guides are described in detail in the acceptance criteria of SRP Section 5.2.3, which is reviewed by MTEB.

5. Fracture Toughness

The acceptance criteria for this area of review are the requirements of Appendix G of 10 CFR Part 50. These criteria satisfy the requirements of GDC 31 and § 50.55a(i) regarding materials testing and acceptance standards for fracture toughness.

Appendix G requires that the reactor vessel and appurtenances thereto which are made of ferritic materials shall meet the following minimum requirements for fracture toughness during system hydrostatic tests, during conditions of normal operation, and during anticipated operational occurrences:

a. The ferritic materials shall be tested in accordance with the ASME Code section NB-2300 including:

(1) $T_{NDT}$ shall be determined for each material by means of a drop-weight test.

(2) The materials shall meet the acceptance standards of paragraph NB-2330 of the Code, which states that at a temperature not greater than ($T_{NDT}$ + 60°F) each Charpy $C_v$ specimen tested shall exhibit at least 35 mils lateral expansion and not less than 50 ft-lbs of absorbed energy.

(3) When these requirements are met, $T_{NDT}$ is defined as the reference temperature, $RT_{NDT}$. In the event that the above requirements are not met, additional $C_v$ notch impact tests are performed (in groups of three specimens) to determine the temperature $T_{cv}$ at which they are met. In this case the reference temperature $RT_{NDT} = T_{cv}$ - 60°F. Thus the reference temperature $RT_{NDT}$ is the higher of $T_{NDT}$ and ($T_{cv}$ - 60°F).

(4) When a $C_v$ impact test has not been performed at ($T_{NDT}$ + 60°F), or when the $C_v$ impact test at ($T_{NDT}$ + 60°F) does not exhibit a minimum of 50 ft-lbs and 35 mils lateral expansion, a temperature representing a minimum of 50 ft-lbs and 35 mils lateral expansion may be obtained from a full $C_v$ impact curve developed from the minimum data points of all the $C_v$ impact tests performed.

b. In addition to the above criteria, the requirements of paragraphs IV.A.2 and 3 and IV.B of Appendix G of 10 CFR Part 50 shall be met.

(1) Standard Review Plan Section 5.3.2, "Pressure-Temperature Limits," discusses the requirements of paragraphs IV.A.2 and 3 of Appendix G in detail.

(2) The acceptance criteria discussed in paragraph IV.B of Appendix G states that reactor vessel beltline materials shall have a minimum upper-shelf energy as determined from Charpy V-notch impact tests on unirradiated specimens in accordance with paragraph NB-2322a of the Code, Section III, of 75 ft-lbs unless it is demonstrated to the Commission by appropriate data and analyses based on other types of tests that lower values of upper-shelf fracture energy are adequate.

6. <u>Material Surveillance</u>

The material surveillance acceptance criteria are the requirements of Section II of Appendix H of 10 CFR Part 50. Complying with the acceptance criteria satisfies the requirements of GDC 32 regarding an appropriate material surveillance program for the reactor vessel.

Section II of Appendix H requirements are:

a. No material surveillance program is required for reactor vessels for which it can be conservatively demonstrated by analytical methods that have been verified by experimental data and tests performed on comparable vessels, making appropriate allowances for all uncertainties in the measurements, that the peak neutron fluence (E > 1 Mev) at the end of the design life of the vessel will not exceed $10^{17}$ $n/cm^2$.

b. Reactor vessels constructed of ferritic materials which do not meet these conditions shall have their beltline regions monitored by a surveillance program complying with the American Society for Testing and Materials (ASTM) standard "Recommended Practice for Surveillance Tests for Nuclear Reactor Vessels," ASTM Designation E-185, except as modified by Appendix H to 10 CFR Part 50.

c. The surveillance program shall meet the following requirements:

(1) Surveillance specimens shall be taken from locations alongside the fracture toughness test specimens required by Section III of Appendix G of 10 CFR Part 50. The specimen types shall comply with the requirements of Section III.A of Appendix G, except that dropweight specimens are not required.

(2) Surveillance capsules containing the surveillance specimens shall be located near the inside vessel wall in the beltline region, so that the neutron flux received by the specimens approximates that received by the vessel inner surface, and the thermal environment is as close as practical to that of the vessel inner surface. If the capsule holders are attached to the vessel wall or cladding, inspection shall be done according to the requirements for permanent structural attachments as given in ASME Code Sections III and XI. The design and location of the capsules shall permit insertion of replacement capsules. Accelerated irradiation capsules may be used in addition to the required number of surveillance capsules specified in paragraph II.C.3 of Appendix H.

(3) The required number of capsules, which will vary from three to five depending upon the adjusted reference temperature at the end of the service lifetime of the reactor vessel, and their withdrawal schedules, shall be in accordance with the requirements of paragraph II.C.3 of Appendix H.

(4) For multiple reactors located at a single site, an integrated surveillance program may be authorized by the Commission on an individual case basis, depending on the degree of commonality and the predicted severity of irradiation.

7. Reactor Vessel Fasteners

The acceptance criteria for the reactor vessel bolting material are given by paragraph IV.A.3 of Appendix G to 10 CFR Part 50 and by the recommendations of Regulatory Guide 1.65, "Materials and Inspections for Reactor Vessel Closure Studs." These acceptance criteria satisfy the quality standards requirements of GDC 1, GDC 30, and § 50.55a, and meet the requirements of GDC 31 regarding prevention of fracture of the RCPB.

Regulatory Positions C.1 and C.2 of Regulatory Guide 1.65 recommend the following:

a. Materials for reactor vessel studs (and other fasteners) that are considered suitable are SA-540 Grades B-23 and B-24, SA-193 Grade B-7, SA-194 Grade 7, and SA-320 Grade L-43, as presented in Section II of the ASME Code.

b. The fastener material should not have an ultimate tensile strength over 170 ksi, and the fracture toughness tests and acceptance levels of paragraph IV.A.3 of Appendix G to 10 CFR Part 50 must be met as detailed in paragraph NB-2333 of Section III of the Code.

c. Surface treatments, plating, or thread lubricants used must be shown to be compatible with the materials, and stable at operating temperatures.

d. Nondestructive examination should be performed according to Section III of the Code, subarticle NB-2580, and including additional recommendations given in Regulatory Position C.2 of Regulatory Guide 1.65.

## III. REVIEW PROCEDURES

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

For each area of review specified in subsection I of this SRP section, the review procedure is as follows:

1. Material Specifications

   The material specifications for the reactor vessel and its appurtenances are compared with the acceptable specifications listed in the Code, Section III, Appendix I, and Section II, Parts A, B, C.

   Materials not listed in the Code, or deviations in a listed specification, are clearly identified, and the bases for deviation or nonconformance evaluated. A study of the suitability of the material and comparisons with precedents set in earlier cases enable the reviewer to determine the acceptability of the proposed exceptions. In those instances where the Materials Engineering Branch has taken exception to the use of a specific material, or questions certain aspects of a specification, the applicant is advised which material is not acceptable, and the reason for disapproval.

2. Special Processes Used for Manufacture and Fabrication of Components

   Information on special processes used for manufacture and fabrication of the reactor vessel and its appurtenances is reviewed to (1) identify each special process, (2) determine whether there are any Code restrictions on its use, (3) establish the adequacy of the process in providing components with suitable mechanical and physical properties, (4) establish the effects of such processes on the stress-corrosion characteristics of the material, and (5) identify whether special requirements for nondestructive examination are needed if the process is used.

Since there are no specific Code requirements on the use of special processes, the suitability of a process is assessed on the basis of service experience with similar parts fabricated by the process being reviewed.

3. Special Methods for Nondestructive Examination

Section V of the Code includes methods for performing nondestructive examinations to detect surface and internal discontinuities when these methods are referenced by Section III of the Code. They include the following methods: radiographic, magnetic particle, liquid penetrant, and ultrasonic. The methods as described are applicable to most geometric configurations and materials encountered in fabrication, and are applied for normal conditions. However, special configurations and materials may require modified methods and techniques. If such special procedures are developed, the reviewer must determine that they are equivalent or superior to the techniques described in Section V of the Code, and are capable of producing meaningful results under the special conditions.

Such special procedures may be modifications or combinations of methods described in Section V, or may be entirely different, but the reviewer verifies that they have been proven by demonstration to result in an examination capable of detecting discontinuities under the special conditions to the same extent that applicable normal techniques which are included in Section V would result in detection of discontinuities under normal conditions.

Such special procedures are submitted to the authorized inspector or inspecting agency for review and approval prior to use.

4. Special Controls and Special Processes Used for Ferritic Steels and Austenitic Stainless Steels

The controls on welding of ferritic steels and austenitic stainless steels discussed in Standard Review Plan Section 5.2.3, "Reactor Coolant Pressure Boundary Materials," are considered applicable to welding of the reactor vessel and its components. The reviewer verifies that any special welding control or special welding process is able to conform to the qualification requirements of the Code, Section IX, or that justification is made for this deviation.

The reviewer also reviews the controls (before, during, and after welding of austenitic stainless steel) to avoid contamination and sensitization that could increase the possibility of stress corrosion cracking in austenitic stainless steel. Additionally, controls to avoid underclad cracking during weld cladding of the reactor vessel are reviewed.

5. Fracture Toughness

The information submitted by the applicant relative to tests for fracture toughness is reviewed for conformance with the Code, Section III, paragraph NB-2300, and Appendix G of 10 CFR Part 50.

These tests include Charpy V-notch impact tests and dropweight tests. A description of the tests is reviewed, and the location of the test specimens and their orientation are verified.

Information regarding calibration of instruments and equipment is reviewed for conformance to Code Section III, paragraph NB-2300.

In the event that none of the fracture toughness tests has been performed, the preliminary safety analysis report (PSAR) must contain a statement of the applicant's intention to perform this work in accordance with Code Section III, NB-2300 and Appendix G of 10 CFR Part 50.

The final safety analysis report (FSAR) is reviewed to ensure that all the impact tests shown in NB-2300 have been performed. The results of the tests shall be in accordance with the acceptance criteria shown in subsection II.5 of this SRP section.

For those plants that were designed and constructed prior to the effective date of Appendix G, 10 CFR Part 50, some of the fracture toughness requirements of Appendix G may not be explicitly met. The detailed procedure for conducting the review of such cases is found in SRP Section 5.3.2, "Pressure-Temperature Limits," and in MTEB Branch Technical Position 5-2, "Fracture Toughness Requirements." Exemptions from the regulation can only be granted when the applicant has demonstrated equivalence to the required margin of safety.

6. Material Surveillance

The reviewer verifies that the information contained in the SAR and the Technical Specifications is complete enough to determine that the surveillance program will comply with Appendix H, 10 CFR Part 50. The following information must be provided as a minimum:

a. The reviewer verifies that the PSAR states the end-of-life fluence calculated for the vessel beltline, the maximum predicted shift in reference transition temperature ($RT_{NDT}$), the number of capsules, and the number and types of specimens to be placed in the capsules, and that the program is in compliance with ASTM E 185 and Appendix H, 10 CFR Part 50.

b. The reviewer verifies that the FSAR provides the information listed above and, in addition, includes results of all fracture toughness tests, chemical analyses of all materials in the beltline region, and provides the information needed by the reviewer to evaluate the adequacy of the program.

7. Reactor Vessel Fasteners

The reviewer verifies that the information in the SAR covers all requirements for reactor vessel studs and other fasteners, as described in the previous section. For FSARs, the results of tensile and fracture toughness tests performed on the fastener materials are checked to ensure that all requirements are met.

## IV. EVALUATION FINDINGS

The reviewer verifies that sufficient and adequate information has been provided to satisfy the requirements of the SRP section, and that his evaluation supports the conclusions of the following type, to be included in the staff's safety evaluation report.

The staff concludes that the reactor vessel materials are acceptable and meet the requirements of General Design Criteria 1, 4, 14, 30, 31, and 32 of Appendix A of 10 CFR Part 50; the material testing and monitoring requirements of Appendices B, G, and H of 10 CFR Part 50; and the requirements of §50.55a of 10 CFR Part 50. This conclusion is based on the following:

1. The materials used for construction of the reactor vessel and its appurtenances have been identified by specification and found to be in conformance with Section III of the ASME Code. Special requirements of the applicant with regard to control of residual elements in ferritic materials have been identified and are considered acceptable. Compliance with the above Code provisions for material specifications satisfies the quality standards requirements of GDC 1, GDC 30, and §50.55a.

2. Special processes used for manufacture or fabrication of the reactor vessel and its appurtenances have been identified, and appropriate data reports on each process as required by Section III of the ASME Code have been submitted by the applicant. Since certification has been made by the applicant that the materials and fabrication requirements of Section III of the Code have been complied with, the special processes used are considered acceptable. Compliance with these Code provisions meets the quality standards requirements of GDC 1, GDC 30, and §50.55a.

3. Special methods used for nondestructive examination of the reactor vessel and its appurtenances have been identified and have been found equivalent or superior to the techniques described in Appendix X of Code Section III. Demonstrations have been made using these special techniques and have satisfied all requirements of the Code. The special methods of nondestructive examination are deemed acceptable. This acceptability based on the Code provisions satisfies the quality standards requirements of GDC 1, GDC 30, and §50.55a.

4. Special controls and special welding processes used for welding the reactor vessel and its appurtenances have been identified and found to be qualified in accordance with the requirements of Code Sections III and IX. Qualification in accordance with the Code provisions meets the requirements of GDC 1, GDC 30, and §50.55a concerning quality standards.

5. When welding components of ferritic steels as identified in Item 4 above, Code controls are supplemented by conformance with the recommendations of regulatory guides as follows:

    a. The controls imposed on welding preheat temperatures are in comformance with the recommendations of Regulatory Guide 1.50, "Control of Preheat Temperature for Welding of Low-Alloy Steel," since these controls provide reasonable assurance that cracking of components made from low alloy steels will not occur during fabrication and minimize the potential for subsequent cracking. These controls also satisfy the quality standards requirements of GDC 1, GDC 30, and §50.55a.

    b. The controls imposed on electroslag welding of ferritic steels are in conformance with the recommendations of Regulatory Guide 1.34, "Control of Electroslag Weld Properties," because the welds fabricated by the process will ensure high integrity and will have a sufficient degree of toughness to furnish adequate safety margins. These controls satisfy the quality standards requirements of GDC 1, GDC 30, and §50.55a.

c. The controls imposed during weld cladding of ferritic steel components are in conformance with the recommendations of Regulatory Guide 1.43, "Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components," because the process used provides reasonable assurance that under clad cracking will not occur during the weld cladding process. These controls satisfy the quality standards requirements of GDC 1, GDC 30, and §50.55a.

6. When welding components of austenitic stainless steels, Code controls are supplemented by conformance with the recommendations of regulatory guides as follows:

   a. The controls imposed on delta ferrite in austenitic stainless steel welds are in conformance with the recommendations of Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal," because the controls used provide reasonable assurance that the welds will not contain micro cracks. These controls also satisfy the quality standards requirement of GDC 1, GDC 30, and §50.55a and the requirements of GDC 14 regarding fabrication to prevent RCPB rapid propagating failure.

   b. The controls imposed on electroslag welding of austenitic stainless steels are in conformance with the recommendations of Regulatory Guide 1.34, for the same reason as stated in item 5b discussed above.

7. The controls (during, all stages of welding) to avoid contamination and sensitization that could cause stress-corrosion cracking in austenitic stainless steels conform with the recommendations of regulatory guides as follows:

   a. The controls to avoid contamination and sensitization of austenitic stainless steel are in conformance with the recommendations of Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel," because the controls used provide assurance that welded components will not be contaminated nor sensitized prior to and during the welding process. These controls satisfy the quality standards requirement of GDC 1, GDC 30, and §50.55a and the GDC 4 requirement relative to material compatibility.

   b. The controls regarding onsite cleaning and cleanliness control of austenitic stainless steel are in comformance with the recommendations of Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants," because the controls used provide assurance that austenitic stainless steel components will be properly cleaned onsite. The controls satisfy Appendix B of 10 CFR Part 50 regarding controls for onsite cleaning of materials and components.

8. Fracture toughness of the reactor vessel and its appurtenances is controlled by conformance with Appendix G, 10 CFR Part 50, which specifies ASME Code provisions and supplementary requirements of Appendix G, 10 CFR Part 50. The fracture toughness tests required by the ASME Code and by Appendix G of 10 CFR Part 50 provide reasonable assurance that adequate safety margins against the possibility of nonductile behavior or rapidly propagating fracture can be established for all pressure-retaining components of the reactor coolant boundary. The use of Appendix G of the Code as a guide in establishing safe operating procedures, and use of the results of the fracture toughness tests performed in accordance with the Code and NRC regulations, will provide adequate safety margins during operating, testing, maintenance, and postulated accident conditions. Compliance with the provisions of Appendix G, 10 CFR Part 50, satisfies the requirements of GDC 14, GDC 31, and §50.55a regarding prevention of fracture of the reactor coolant pressure boundary.

9. Changes in the fracture toughness of material in the reactor vessel beltline caused by exposure to neutron radiation have been assessed properly, and adequate safety margins against the possibility of vessel failure are provided as the material surveillance requirements of ASTM E 185 and Appendix H, 10 CFR Part 50, are met. Compliance with these documents assures that the surveillance program constitutes an acceptable basis for monitoring radiation-induced changes in the fracture toughness of the reactor vessel material and satisfies the requirements of GDC 32 regarding an appropriate material surveillance program for the reactor vessel.

10. Integrity of the reactor vessel studs and fasteners is assured by conformance with the recommendations of Regulatory Guide 1.65, "Materials and Inspections for Reactor Vessel Closure Studs." Compliance with these recommendations satisfies the quality standards requirements of GDC 1, GDC 30, and §50.55a; the prevention of fracture of the RCPB requirement of GDC 31; and the requirements of Appendix G, 10 CFR Part 50, as detailed in the provisions of the ASME Code, Sections II and III.

## V. IMPLEMENTATION

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

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

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

## VI. REFERENCES

1. 10 CFR Part 50, Section 50.55a, "Codes and Standards."

2. 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Plants." (Criterion 1, "Quality Standards and Records"; Criterion 4, "Environmental and Missile Design Bases"; Criterion 14, "Reactor Coolant Pressure Boundary"; Criterion 30, "Quality of Reactor Coolant Pressure Boundary"; Criterion 31,

"Fracture Prevention of Reactor Coolant Pressure Boundary"; and Criterion 32, "Inspection of Reactor Coolant Pressure Boundary.")

3. 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants."

4. 10 CFR Part 50, Appendix G, "Fracture Toughness Requirements."

5. 10 CFR Part 50, Appendix H, "Reactor Vessel Material Surveillance Program Requirements."

6. ASME Boiler and Pressure Vessel Code, Sections II, III, V, IX, XI, American Society of Mechanical Engineers.

7. ASTM E-185, "Surveillance Tests on Structural Materials in Nuclear Reactors," Annual Book of ASTM Standards, Part 30, American Society for Testing and Materials.

8. Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal."

9. Regulatory Guide 1.34, "Control of Electroslag Weld Properties."

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

11. Regulatory Guide 1.43, "Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components."

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

13. Regulatory Guide 1.50, "Control of Preheat Temperature for Welding of Low-Alloy Steel."

14. Regulatory Guide 1.65, "Materials and Inspections for Reactor Vessel Closure Studs."