U.S. NUCLEAR REGULATORY COMMISSION

# STANDARD REVIEW PLAN

## 5.2.3 REACTOR COOLANT PRESSURE BOUNDARY MATERIALS

### REVIEW RESPONSIBILITIES

**Primary** - Organization responsible for review of component integrity issues related to reactor coolant pressure boundary

**Secondary** - Organization responsible for the review of component integrity issues related to reactor vessels

Organization responsible for the review of component integrity issues related to steam generator tubes

Organization responsible for the review of chemical engineering issues

Organization responsible for the review of materials engineering issues related to flaw evaluation and welding

## I. AREAS OF REVIEW

The following areas relating to materials of the reactor coolant pressure boundary (RCPB) other than the reactor pressure vessel - which is covered in Standard Review Plan (SRP) Section 5.3.1, “Reactor Vessel Materials,” - are reviewed:

1. Material Specifications. The specifications for pressure-retaining ferritic materials, nonferrous metals and austenitic stainless steels, including weld materials, that are used for each component (e.g., vessels, piping, pumps, and valves) of the reactor coolant pressure boundary, are reviewed by the primary reviewer with support from the secondary reviewers.
The adequacy and suitability of the ferritic materials, stainless steels, and nonferrous metals specified for the above applications are determined.

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2. Compatibility of Materials with the Reactor Coolant. General corrosion and stress corrosion cracking induced by impurities in the reactor coolant can cause failures of the reactor coolant pressure boundary.

The chemistry of the reactor coolant and the additives (such as inhibitors) whose function is to control corrosion is reviewed by the organization responsible for chemical engineering issues as part of its primary review responsibility for SRP Sections 5.4.8 and 9.3.4.

The organization responsible for chemical engineering issues also reviews the compatibility of the materials of construction employed in the RCPB with the reactor coolant, contaminants, or radiolytic products to which the system is exposed. The extent of the corrosion of ferritic low alloy steels and carbon steels in contact with the reactor coolant is reviewed.

Similarly, the primary review organization reviews possible uses of austenitic stainless steels in the sensitized condition and nickel-chromium-iron alloys. The use of austenitic stainless steels in any condition in boiling water reactors (BWRs) requires special attention because of the oxygen content of BWR coolant. The use of nickel-chromium-iron alloys in the RCPB of pressurized water reactors (PWRs) requires attention due to primary water stress corrosion cracking of certain nickel-chromium-iron alloys.

3. Fabrication and Processing of Ferritic Materials

A. The fracture toughness properties of ferritic materials used for pressure-retaining components of the reactor coolant pressure boundary are reviewed.

The fracture toughness tests performed on all ferritic materials used for pressure-retaining RCPB components (i.e., vessels, pumps, valves, and piping) are reviewed.

The test procedures used for Charpy V-notch impact and dropweight testing are reviewed.

Fracture toughness of the material is characterized by its reference temperature, $RT_{NDT}$. This temperature is the higher of the nil ductility temperature (NDT) from the dropweight test or the temperature that is 33°C (60°F) below the temperature at which Charpy V-notch impact test data are 68 J (50 ft-lbs) and 0.89 mm (35 mils) lateral expansion.

B. The control of welding in ferritic steels is reviewed.

(1) The quality of welds in low alloy steels can be increased significantly by proper controls. In particular, the propensity for cold cracks or reheat cracks to form in areas under the bead and in heat-affected zones (HAZ) can be minimized by maintaining proper preheat temperatures of the base metal concurrent with controls on other welding variables. The

minimum preheat temperature and the maximum interpass temperatures are reviewed.

(2) The quality of electroslag welds in low alloy steel components can be increased by maintaining a weld solidification pattern that possesses a strong intergranular bond in the center of the weld. The welding variables, which have a significant effect on the weld solidification pattern, must be controlled. The welding variables, solidification patterns, macro etch tests, and Charpy V-notch impact tests of electroslag welds are reviewed. It should be noted that electroslag welds characteristically exhibit a low degree of fusion between the base metal and such welds. Electroslag welds, where used in the RCPB, are reviewed with respect to regulatory guidance describing acceptable controls for the electroslag weld process.

(3) Experience shows that a welder qualified to weld low-alloy steel or carbon steel components under normal fabricating conditions may not produce acceptable welds if the accessibility to the weld area is restricted. Limited accessibility can occur when component parts are joined in the final assembly or at the plant site, where other adjacent components or structures prevent the welder from assuming an advantageous position during the welding operation. The adequacy of accessibility during the welding of ferritic components is reviewed.

(4) Controls can be exercised to limit the occurrence of underclad cracking in low-alloy steel components clad with stainless steel. Welding processes that generate excessive heating and promote base metal coarsening cause underclad cracking of certain steels. These variables are reviewed.

C. The requirements for nondestructive examination of ferritic wrought seamless tubular products used for ASME Class 1 components of nuclear power plants are specified in Paragraphs NB-2550 through NB-2570, ASME Boiler and Pressure Vessel Code (hereafter “the Code”), Section III, “Rules for Construction of Nuclear Facility Components.” The methods of examination specified for nondestructive examination are reviewed.

4. Fabrication and Processing of Austenitic Stainless Steel. Austenitic stainless steels in a variety of product forms (including several stabilized product forms) are used for construction of pressure-retaining components in the reactor coolant pressure boundary. Unstabilized austenitic type stainless steels, which include American Iron and Steel Institute (AISI) Types 304 and 316, are more frequently used. Because these compositions are susceptible to stress corrosion cracking when exposed to certain environmental conditions, process controls must be exercised during all stages of component manufacturing and reactor construction to avoid severe sensitization of the material and to minimize exposure of the stainless steel to contaminants that could lead to stress corrosion cracking.

Item 4.C is reviewed by the organization responsible for chemical engineering issues and on request it will review corrosion testing data.

A. Sensitization is caused by intergranular precipitation of chromium carbide in austenitic stainless steels that are exposed to temperatures in the approximate range of 430°C to 820°C (800°F to 1500°F). Precipitation of the chromium carbide at the grain boundaries increases with increasing carbon content and exposure time. Control of the application and processing of stainless steel is needed to eliminate the occurrences of stress corrosion cracking in sensitized stainless steel components of nuclear reactors. Test data and service experience demonstrate that sensitized stainless steel is significantly more susceptible to stress corrosion cracking than nonsensitized (solution heat treated) stainless steel.

The following areas are reviewed: requirements for solution heat treatment of stainless steel; plans to avoid partial or severe sensitization during welding, including information on welding methods, heat input, and interpass temperatures; and a description of the material inspection program that will be used to verify that unstabilized austenitic stainless steels are not susceptible in service to intergranular attack.

Special provisions may apply to the use of austenitic stainless steel in BWR piping because plant operating experience indicates that reactor coolant boundary piping is susceptible to oxygen-assisted stress corrosion cracking.

B. Contamination of austenitic stainless steel with halogens and halogen-bearing compounds (e.g., die lubricants, marking compounds, and masking tape) must be avoided to the maximum degree possible to avoid stress corrosion cracking. Plans for cleaning and protecting the material against contaminants capable of causing stress corrosion cracking during fabrication, shipment, storage, construction, testing, and operation of components and systems are reviewed. Controls for abrasive work (e.g., grinding) on austenitic stainless steel surfaces are also reviewed with respect to potential for material contamination and excessive surface cold-working. Any pickling used in processing austenitic stainless steel components and the restrictions placed on pickling sensitized materials are reviewed. The upper limit on the yield strength of austenitic stainless steel materials is reviewed.

C. Whether sensitized or not, austenitic stainless steel is subject to stress corrosion cracking and must be protected from contaminants that can promote cracking. Thermal insulation is often employed adjacent to, or in direct contact with, stainless steel piping and components. The contaminants present in the thermal insulation may be leached by spilled or leaking liquids and deposited on the stainless steel surfaces. The controls on the use of nonmetallic thermal insulation are reviewed.

D. Austenitic stainless steel is subject to hot cracking (microfissuring) during welding if the weld metal composition or the welding procedure is not properly controlled. Because cracks formed in this manner are small and difficult to detect by nondestructive testing methods, welding procedures, weld metal compositions, and delta ferrite percentages that minimize the possibility of hot cracking must be specified. The adequacy of the proposed welding procedures, weld metal compositions, testing of weld metals, and delta ferrite content is reviewed.

The assurance of satisfactory electroslag welds for austenitic stainless steel components can be increased by maintaining a weld solidification pattern with a strong intergranular bond in the center of the weld. The welding variables that have a significant effect on the weld solidification pattern must be controlled.

A number of electroslag welding process variables, such as slag pool depth, electrode feed rate and oscillation, current, voltage, and slag conductivity, have been shown to influence the weld solidification pattern. If the combination of process variables produces a deep pool of molten weld metal, the crystal (dendritic) growth direction from the pool sides will join at an obtuse angle at the center of the weld, and cracks may develop because of the weaker centerline bond between dendrites. A proper combination of process variables promotes a dendritic growth pattern with an acute joining angle, which results in a strong centerline bond. The welding variables, solidification patterns, and macro etch tests used in the electroslag welding of austenitic stainless steel are reviewed.

Experience has shown that a welder qualified to weld stainless steel components under normal fabricating conditions may not produce acceptable welds if the accessibility to the weld area is restricted. Limited accessibility can occur when component parts are joined in the final assembly or at the plant site, where other adjacent components or structures prevent the welder from assuming an advantageous position during the welding operation. The adequacy of accessibility of field erected structures, for welding austenitic stainless steel components, is reviewed.

E. The requirements for nondestructive examination of wrought seamless tubular products used for components of nuclear power plants are specified in Paragraphs NB-2550 through NB-2570 of the Code, Section III. Nondestructive examination techniques applied to tubular products used for components of the RCPB, or other safety-related ASME Class 1 systems that are designed for pressure in excess of 1.896 MPa (275 psig) or temperatures in excess of 93°C (200°F), must be capable of detecting unacceptable defects regardless of defect shape, orientation, or location in the product.

   The nondestructive examination procedures used for inspection of tubular products are reviewed.

F. Where cast austenitic stainless steel components are proposed for use in the RCPB, the adequacy of material fracture toughness properties and welding controls to resist thermal aging effects over the design life are reviewed. Since welds on such materials are difficult to inspect using ultrasonic techniques, the inspectability is also reviewed.

5. <u>Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)</u>. For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this

SRP section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this SRP section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

6. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

7. Operational Program Description and Implementation. For a COL application, the staff reviews the Inservice Inspection and Inservice Testing Programs description and the proposed implementation milestones. The staff also reviews final safety analysis report (FSAR) Table 13.x to ensure that the Inservice Inspection and Inservice Testing Programs and associated milestones are included.

Review Interfaces:

The primary review organization is responsible for ensuring the coordination and interface with secondary review organizations, as necessary.

Other SRP sections interface with this section as follows:

1. The programs for assuring the integrity of bolting and threaded fasteners are reviewed under SRP Section 3.13.

2. The reactor coolant chemistry and associated chemistry controls (including additives such as inhibitors) as it relates to corrosion control and compatibility with RCPB materials, is reviewed under SRP Sections 5.4.8 and 9.3.4.

3. The design for structural integrity of components and their supports including the adequacy of design fatigue curves for RCPB materials with respect to cumulative reactor service-related environmental and usage factor effects, is reviewed under SRP Section 3.9.3.

4. The inservice inspection requirements specified for the RCPB and the proposed inspection and examination techniques to provide early detection and adequate evaluation of defects in materials and weldments used in the RCPB are reviewed under SRP Section 5.2.4.

5. The quality assurance program is reviewed under SRP Chapter 17.

6. For COL reviews of operational programs, the review of the applicant's implementation plan is performed under SRP Section 13.4, "Operational Programs."

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

## II. ACCEPTANCE CRITERIA

### Requirements

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

1. General Design Criteria (GDC) 1 and 30 found in Appendix A to Part 50, as they relate to quality standards for design, fabrication, erection and testing;

2. GDC 4, as it relates to the compatibility of components with environmental conditions;

3. GDC 14 and 31, as they relate to minimizing the probability of rapidly propagating fracture and gross rupture of the RCPB;

4. Appendix B to Part 50, Criterion XIII, as it relates to onsite material cleaning control;

5. Appendix G to Part 50, as it relates to materials testing and acceptance criteria for fracture toughness of the RCPB;

6. Section 50.55a, as it relates to quality standards applicable to the RCPB;

7. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations;

8. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

### SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. Material Specifications. The requirements of GDC 1, GDC 30, and § 50.55a regarding quality standards are met for material specifications by compliance with the applicable provisions of the ASME Code and by acceptable application of materials Code Cases as described in Regulatory Guide 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III."

   The specifications for permitted materials are those identified in the ASME Code, Section III, Appendix I, or described in detail in the ASME Code, Section II, "Materials, Parts A, B, and C. Regulatory Guide 1.84 describes acceptable materials Code Cases and guidelines for their application in light-water-cooled nuclear power plants that may be used in conjunction with the above specifications.

   Staff positions related to BWR piping materials and materials processing are described in Attachment A to Generic Letter 88-01. The technical bases for the positions provided in Generic Letter 88-01 and similar recommendations related to minimizing stress corrosion cracking in susceptible piping of BWRs are detailed in NUREG-0313.

2. Compatibility of Materials with the Reactor Coolant. The requirements of GDC 4 relative to compatibility of components with environmental conditions are met by compliance with the applicable provisions of the ASME Code and by compliance with the positions of Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel."

   Ferritic low alloy steels and carbon steels, which are used in many principal pressure-retaining components, are clad with a layer of austenitic stainless steel. If cladding is not used, conservative corrosion allowances must be indicated for all exposed surfaces of carbon and low alloy steels, as indicated in the ASME Code, Section III, NB-3121, "Corrosion."

   Regulatory Guide 1.44 contains staff positions related to unstabilized austenitic stainless steel of the AISI Type 3XX series used for components of the RCPB. Positions related to BWR piping materials, including verification of nonsensitization of the material by an approved test, are described in Attachment A to Generic Letter 88-01. The technical bases for the positions provided in Generic Letter 88-01 and similar recommendations related to minimizing stress corrosion cracking in susceptible piping of BWRs are detailed in NUREG-0313, Revision 2.

3. Fabrication and Processing of Ferritic Materials

   A. The acceptance criteria for fracture toughness are the requirements of Appendix G, "Fracture Toughness Requirements," of 10 CFR Part 50. These criteria satisfy the requirements of GDC 14 and GDC 31 regarding prevention of fracture of the RCPB.

      Appendix G requires that the pressure-retaining components of the RCPB that are made of ferritic materials shall meet the requirements for fracture toughness during system hydrostatic tests and any condition of normal operation, including anticipated operational occurrences. With respect to absorbed energy in J (ft-lbs) and lateral expansion as shown by Charpy V-notch ($C_v$) impact tests, all materials shall meet the acceptance standards of Article NB-2300 of the Code, Section III, and the requirements of Sections IV of Appendix G, 10 CFR Part 50, as follows:

(1) Materials for piping (i.e., pipes, tubes, and fittings), pumps, and valves, excluding bolting materials, shall meet the requirements of the Code, Section III, Paragraph NB-2331 or NB-2332 (as applicable based upon thickness), and Appendix G, Paragraph G-3100 to the Code, Section III. The required $C_v$ values for piping, pumps, and valves are specified in Table NB-2332(a)-1 of the Code, Section III.

(2) Materials for bolting for which impact tests are required shall meet the requirements of the Code, Section III, Paragraph NB-2333.

(3) Calibration of instruments and equipment shall meet the requirements of the Code, Section III, Paragraph NB-2360.

The special acceptance requirements and staff positions for fracture toughness of reactor vessels are covered by SRP Section 5.3.1.

B. The acceptance criteria for control of ferritic steel welding are based upon the following regulatory guides and ASME Code provisions to satisfy the quality standards requirements of GDC 1, GDC 30, and § 50.55a:

(1) The amount of specified preheat must be in accordance with the requirements of the Code, Section III, Appendix D, Paragraph D-1210. These requirements are supplemented by positions described in Regulatory Guide 1.50, “Control of Preheat Temperature for Welding of Low Alloy Steel.”

The supplemental acceptance criteria for control of preheat temperature are as follows:

(a) According to the welding procedure qualification minimum preheat and maximum interpass temperatures should be specified and the welding procedure should be qualified at the minimum preheat temperature. For production welds, the preheat temperature should be maintained until a post-weld heat treatment has been performed.

(b) Production welding should be monitored to verify that the limits on preheat and interpass temperatures are maintained. In the event that the above criteria are not met, the weld is subject to rejection.

(2) The acceptance criteria for electroslag welds are presented in Regulatory Guide 1.34, “Control of Electroslag Weld Properties.” These criteria specify acceptable solidification patterns and impact test limits (for

qualification of welds in Class 1 and Class 2 components) and the criteria for verifying conformance during production welding.

(3) Regulatory Guide 1.71, “Welder Qualification for Areas of Limited Accessibility,” provides the following criteria for requalification of welders: the performance qualification should require testing of the welder when conditions of accessibility to a production weld are less than 30 to 35 cm (12-14 inches) in any direction from the joint; and requalification is required for different restricted accessibility conditions or when any of the essential variables listed in the Code, Section IX, “Welding and Brazing Qualifications” are changed.

Qualification of the welder or welding operators for limited accessibility may be waived provided that 100% radiographic and/or ultrasonic examination of the completed welded joint is performed. Examination procedures and acceptance standards should meet the requirements of the ASME Section III of the Code. Records of the examination reports and radiographs should be retained and made part of the Quality Assurance Documentation for the completed weld.

(4) Regulatory Guide 1.43, “Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components,” provides criteria to limit the occurrence of underclad cracking in low-alloy steel safety-related components clad with stainless steel. According to these criteria, material known to have susceptibility to underclad cracking should not be weld clad by high-heat-input welding processes and should be qualified for use to demonstrate that underclad cracking is not induced.

C. For nondestructive examination of ferritic steel tubular products, the requirements of GDC 1, GDC 30, and § 50.55a regarding quality standards are met by compliance with the applicable provisions of the ASME Code.
The acceptance criteria are given in Section III of the Code, Paragraphs NB-2550 through NB-2570.

4. <u>Fabrication and Processing of Austenitic Stainless Steel</u>

A. The requirements of GDC 4 relative to compatibility of components with environmental conditions are met with measures to avoid sensitization in austenitic stainless steels. The acceptance criteria for testing, alloy compositions, and heat treatment, to avoid sensitization in austenitic stainless steels, are covered in Regulatory Guide 1.44 and additional criteria for BWRs are specified in Attachment A to Generic Letter 88-01 based upon the technical information provided in NUREG-0313, Revision 2. Similar recommendations related to minimizing stress corrosion cracking in susceptible piping of BWRs are described in NUREG-0313, Revision 2.

Regulatory Guide 1.44 also identifies acceptable methods for verification of non-sensitization of austenitic stainless steel materials and qualification of welding processes employed in production including testing using ASTM A-262 Practice A or E or another method which can be demonstrated to show non-sensitization.  Alternative tests that have been previously accepted, based upon the adequacy of justifications presented and circumstances of proposed use, include the use of ASTM A-708.

B. The requirements of GDC 4 relative to compatibility of components with environmental conditions are met with additional controls to avoid stress corrosion cracking in austenitic stainless steels.  These controls consist of acceptance criteria on prevention of contamination, cleaning, and upper limit on yield strength.  Additional controls for avoiding stress corrosion cracking are applied to BWRs as described below.

Controls to avoid stress corrosion cracking in austenitic stainless steels are also covered in Regulatory Guide 1.44.  This guide provides acceptance criteria on the cleaning and protection of the material against contaminants capable of causing stress corrosion cracking.  Acid pickling is to be avoided on fabricated stainless steels.  Necessary pickling is to be done only with appropriate controls.  Pickling should not be performed upon sensitized stainless steels.

The quality of water used for final cleaning or flushing of finished surfaces during installation 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."  Vented tanks with deionized or demineralized water are an acceptable source of water for final cleaning or flushing of finished surfaces.  The oxygen content of the water need not be controlled.

The controls for abrasive work on austenitic stainless steel surfaces should, as a minimum, be equivalent to the controls described in Regulatory Guide 1.37 position C.5 to prevent contamination which promotes stress corrosion cracking.  Tools which contain materials that could contribute to intergranular or stress corrosion cracking or which, because of previous usage, may have become contaminated with such materials, should not be used on austenitic stainless steel surfaces.

Laboratory stress corrosion tests and service experience provide the basis for the criterion that cold-worked austenitic stainless steels used in the reactor coolant pressure boundary should have an upper limit on the yield strength of 620 MPa (90,000 psi).

Additional controls, beyond those described above, are warranted to avoid intergranular stress corrosion cracking (IGSCC) in and near welds in BWR austenitic stainless steel piping.  The affected piping and the additional controls are described in Attachment A to Generic Letter 88-01 or NUREG-0313.  These controls include material and weldment specifications for IGSCC resistant materials, processing techniques, categorization of the IGSCC resistance of installations based upon material properties, treatment history, and post-weld treatments.  The technical bases for these controls are described in NUREG-0313.

C. The acceptance criteria for compatibility of austenitic stainless steel with thermal insulation are based on Regulatory Guide 1.36, “Nonmetallic Thermal Insulation for Austenitic Stainless Steel,” to satisfy GDC 14 and 31 relative to prevention of failure of the RCPB. The compatibility of austenitic stainless steel materials with thermal insulation is dependent upon the type of insulation. The thermal insulation is acceptable if either reflective metal insulation is employed or a nonmetallic insulation which meets the criteria of Regulatory Guide 1.36 is used. The acceptance criteria for nonmetallic insulation for stainless steel are based on the levels of leachable contaminants in the material and are presented in position C.2.b and Figure 1 of the guide.

D. The acceptance criteria for control of welding of austenitic stainless steels are based on NUREG-0313 as described below and on Regulatory Guides 1.31, 1.34, and 1.71, to satisfy the quality standards requirements of GDC 1, GDC 30, and 10 CFR 50.55a.

The acceptance criteria for delta ferrite in austenitic stainless steel welds are given in Regulatory Guide 1.31, “Control of Ferrite Content in Stainless Steel Weld Metal.” These acceptance criteria cover (1) verification of delta ferrite content of filler metals, (2) ferrite measurement, (3) instrumentation, (4) acceptability of test results, and (5) documentation of weld pad verification tests. For the BWR austenitic stainless steel RCPB piping specified in Generic Letter 88-01, the weld metal ferrite content should be controlled as described in the positions of Attachment A to Generic Letter 88-01 or the recommendations of NUREG-0313, Revision 2.

The acceptance criteria for electroslag welds in austenitic stainless steel are given in Regulatory Guide 1.34, “Control of Electroslag Weld Properties.” These criteria specify acceptable solidification patterns for qualification of austenitic stainless steel welds and the basis for verifying conformance during production welding.

Regulatory Guide 1.71 provides the following criteria for requalification of welders:

(1) The performance qualification should require testing of the welder when conditions of accessibility to a production weld are less than 30 to 35 cm (12-14 inches) in any direction from the joint.

(2) Requalification should be required for different restricted accessibility conditions or when other essential variables listed in the Code, Section IX, are changed. An alternate acceptance criterion is as stated in Subsection II.3.B of this SRP section.

E. For nondestructive examination of austenitic stainless steel tubular products, the quality standards requirements of GDC 1, GDC 30, and § 50.55a are met by compliance with the applicable provisions of the ASME Code. The acceptance criteria are given in Section III of the Code, Paragraphs NB-2550 through NB-2570.

G. Operational Programs. For COL reviews, the description of the operational program and proposed implementation milestones for the Inservice Inspection and Inservice Testing Programs are reviewed in accordance with 10 CFR 50.55a(g) and 10 CFR 50, Appendix A. The implementation milestones in the Inservice Inspection and Inservice Testing Programs are identified under SRP Section 5.2.4.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. GDC 1 and 10 CFR 50.55a require that structures, systems, and components (SSCs) be designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with the importance of the safety function to be performed. 10 CFR 50.55a also incorporates by reference applicable editions and addenda of the ASME Boiler and Pressure Vessel Code. GDC 30 requires that components which are part of the reactor coolant pressure boundary be designed, fabricated, erected, and tested to the highest quality standards practical. The reactor coolant pressure boundary provides a fission product barrier, a confined volume for the inventory of reactor coolant, and flow paths to facilitate core cooling. Application of 10 CFR 50.55a, GDC 1, and GDC 30 to the RCPB materials provides assurance that established standard practices of proven or demonstrated effectiveness are used to achieve a high likelihood that these safety functions will be performed.

2. GDC 4 requires that SSCs important to safety be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operations, maintenance, testing, and postulated accidents, including LOCAs. The RCPB provides a fission product barrier, a confined volume for the inventory of reactor coolant, and flow paths to facilitate core cooling. Application of GDC 4 to the RCPB materials provides assurance that degradation and/or failure of the RCPB resulting from environmental service conditions that could cause substantial reduction in capability to contain reactor coolant inventoryor to confine fission products, or cause interference with core cooling are not likely to occur.

3. GDC 14 requires that the RCPB be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture. The RCPB provides a fission product barrier, a confined volume for the inventory of reactor coolant, and flow paths to facilitate core cooling. Application of GDC 14 to the RCPB materials assures that they are selected, fabricated, installed, and tested to provide a low probability of significant degradation and, which in the case of extreme degradation could cause gross failure of the RCPB resulting in substantial reduction in capability to contain reactor coolant inventory, reduction in capability to confine fission products, or interference with core cooling.

4. GDC 31 requires that the RCPB be designed with sufficient margin to assure that when stressed under operating, maintenance, testing, and postulated accident conditions (1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The design is required to reflect consideration of

service temperatures and other conditions of the boundary material under operating, maintenance, testing, and postulated accident conditions and the uncertainties in determining (1) material properties, (2) the effects of irradiation on material properties, (3) residual, steady state and transient stresses, and (4) size of flaws. The RCPB provides a fission product barrier, a confined volume for the inventory of reactor coolant, and flow paths to facilitate core cooling. Application of GDC 31 to the RCPB materials assures that they are selected to provide sufficient design margin to account for uncertainties associated with flaws and the effects of service and operating conditions, and thereby to provide a minimum probability of material degradation leading to rapid failure. The probability of substantial reduction in capability to contain reactor coolant inventory, reduction in capability to confine fission products, and interference with core cooling is thereby minimized.

5. Appendix G of 10 CFR Part 50 requires that the fracture toughness of RCPB ferritic materials be tested in accordance with the requirements of the ASME Code and that the pressure-retaining components of the RCPB that are made of ferritic materials meet requirements for fracture toughness during system hydrostatic tests and any condition of normal operation, including anticipated operational occurrences. Application of these requirements to the RCPB materials provides a method of satisfying the requirements of GDCs 14 and 31 related to fracture prevention. The rationale for these requirements is discussed in Items 3 and 4 above.

6. Appendix B of 10 CFR Part 50 requires, in Criterion XIII, that measures be established to control the cleaning of material and equipment to prevent damage or deterioration. The RCPB provides a fission product barrier, a confined volume for the inventory of reactor coolant, and flow paths to facilitate core cooling. Application of cleaning requirements to the RCPB materials provides assurance that contaminants to which they could be exposed will not damage or deteriorate the materials, alter their properties, accelerate effects associated with aging, or increase the susceptibility to failure mechanisms such as stress corrosion cracking. This reduces the likelihood of degradation and/or failure of the RCPB that could cause substantial reduction in capability to contain reactor coolant inventory or to confine fission products, or cause interference with core cooling.

## III. REVIEW PROCEDURES

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

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. Material Specifications. The material specifications for each major pressure-retaining component or part used in the RCPB are compared with the acceptable specifications listed in the Code, Sections II, Part D, acceptable material Code Cases as identified in Regulatory Guide 1.84, staff positions on BWR materials described in Attachment A to Generic Letter 88-01, and/or the recommendations of NUREG-0313, Revision 2, as stated in the acceptance criteria. Exceptions to the material specifications of the Code

are clearly identified, and the basis evaluated. The reviewer judges the significance of the exceptions and, taking into account precedents set in earlier cases, determines the acceptability of the proposed exceptions. In those instances where the primary reviewer takes 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 for what reason.

Operating experience has indicated that certain nickel-chromium-iron alloys (e.g. Alloy 600 and associated weld materials, Alloy 82 and 182) are susceptible to stress corrosion cracking as documented in NUREG-1823 and NRC Generic Letter 97-01. The NRC Order EA-03-009 was issued to provide interim inspection requirements for reactor pressure vessel heads (including penetration nozzles) at pressurized water reactors. Alloy 690 and associated weld materials Alloy 52 and 152 have improved corrosion resistance in comparison to Alloy 600 used in PWR RCPB applications. Where nickel-chromium-iron alloys are proposed for use in the PWR RCPB, use of Alloy 690 materials is preferred. If use of Alloy 600 materials is proposed, the reviewer verifies that an acceptable technical basis is either identified (based upon demonstrated satisfactory use in similar applications) or presented by the applicant to support use of the material under the expected environmental conditions (e.g., exposure to the reactor coolant). In addition the reviewer verifies that acceptable augmented inspection requirements have been proposed based on operating experience and service conditions. For all RCPB environments, particular review emphasis is placed upon the corrosion resistance and stress corrosion cracking resistance properties of the proposed nickel-chromium-iron alloy(s).

Where cast austenitic stainless steels are proposed for use in the RCPB, the reviewer verifies that the material specifications ensure adequate fracture toughness over the design life to support use of the material under the expected environmental conditions (e.g., exposure to the reactor coolant operating temperatures).

2. Compatibility of Materials with the Reactor Coolant. The reviewer verifies that the following information is provided at each respective stage of the review process:

   A. At the construction permit stage of review:

      (1) A list of the materials of construction of the components of the reactor coolant pressure boundary that are exposed to the reactor coolant, including a description of material compatibility with the coolant, contaminants, and radiolytic products to which the materials may be exposed in service.

      (2) A list of the materials of construction of the RCPB, and a description of material compatibility with external insulation and with the environment in the event of reactor coolant leakage.

      (3) The fabrication and cleaning controls imposed on stainless steel components to minimize contamination with chloride and fluoride ions.

   B. At the operating license stage of the review process:

(1) The items listed under Subsection III.2.A above are reviewed to provide assurance that any changes are noted that may have occurred during the period between the submittal of the preliminary and final safety analysis reports.

C. For design certification and COL applications under 10 CFR Part 52, the reviewer verifies the information identified for a construction permit in Section 2.A, above.

3. Fabrication and Processing of Ferritic Materials

A. The information submitted by the applicant relative to tests for fracture toughness is reviewed for conformance with the acceptance criteria stated in Subsection II.3.A. These tests include Charpy V-notch impact and dropweight tests. A description of the tests is reviewed, and the locations of the test specimens and their orientation are verified. Information regarding calibration of instruments and equipment is reviewed for conformance with the acceptance criteria stated in Subsection II.3.A.(3) of this SRP section.

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 the Code, Section III, Paragraph NB-2300 and Appendix G; and the requirements of 10 CFR Part 50, Appendix G.

The final safety analysis report (FSAR) is reviewed to assure that all the impact tests required by Appendix G to 10 CFR Part 50, as detailed in NB-2300, have been performed.

B. The control of welding in ferritic steels is reviewed as described below:

(1) The information submitted by the applicant regarding the control of preheat temperatures for welding low alloy steel is reviewed for conformance with the acceptance criteria stated in Subsection II.3.B.(1) of this SRP section.

(2) The electroslag weld information submitted by the applicant is reviewed for conformance to the acceptance criteria discussed in Subsection II.3.B.(2) of this SRP section. The information in the SAR is reviewed to verify that macroetch tests have been conducted (to assure that an acceptable weld solidification pattern is obtained) and that impact tests specified in Regulatory Guide 1.34 meet the acceptance criteria discussed previously in Subsection II.3.B.(2) of this SRP section.

(3) The ASME Code, Section III, requires adherence to the requirements of Section IX, "Welding and Brazing Qualifications of the Code." One of the requirements is welder qualification for production welds. However, there is a need for supplementing this section of the Code because the

assurance of providing satisfactory welds in locations of restricted direct physical and visual accessibility can be increased significantly by qualifying the welder under conditions simulating the space limitations under which the actual welds will be made.

Regulatory Guide 1.71 provides the necessary supplement to the Code, Section IX, in this respect. The information submitted by the applicant is reviewed for conformance with acceptance criteria discussed in Subsection II.3.B.(3) of this SRP section.

(4) The information submitted by the applicant regarding controls to limit the occurrence of underclad cracking in low alloy steel components when weld cladding with austenitic stainless steel is reviewed for conformance with acceptance criteria given in Subsection II.3.B.(4) of this SRP section.

C. The reviewer verifies that acceptable methods specified in the ASME Code, Section III, paragraphs NB-2550 through NB-2570 are proposed by the applicant for examination of ferritic steel tubular products.

4. Fabrication and Processing of Austenitic Stainless Steels

A. The information submitted by the applicant in the following areas is reviewed for conformance with the acceptance criteria stated in Subsection II.4.A of this SRP section regarding:

(1) The desirable stage in the sequence of processing for solution heat treatment, including the rates of cooling and the quenching media.

(2) Controls to prevent sensitization during welding, as described in Regulatory Guide 1.44.

(3) Controls to verify non-sensitization and to qualify welding processes employed in production, as described in Subsection II.4.A of this SRP section.

(4) For BWRs, additional processing controls, as described in Attachment A to Generic Letter 88-01 (or NUREG-0313, Revision 2).

In the event that information in the above areas is not supplied, sufficient justification for the deviation must be presented.

B. The information submitted by the applicant is reviewed for conformance with the acceptance criteria discussed in Subsection II.4.B of this SRP section as follows:

Verification is sought that process controls are exercised during all stages of component manufacture and reactor construction to minimize the exposure of austenitic stainless steels to contaminants that could lead to stress corrosion cracking.

Information is also checked to assure that precautions have been taken to require removal of all cleaning solutions, processing compounds, degreasing agents, and any other foreign material from the surfaces of the component at any stage of processing prior to any elevated temperature treatment and prior to hydrotests. The reviewer verifies that a statement is contained in the SAR that pickling of sensitized austenitic stainless is avoided and that the quality of water used for final cleaning or flushing of finished surfaces during installation is in accordance with acceptance criteria discussed in Subsection II.4.B of this SRP section.

The applicant's description of abrasive work controls for austenitic stainless steel surfaces is reviewed and is verified adequate to minimize the introduction of stress corrosion cracking promoting contaminants and the cold-working of surfaces.

Because excessive cold work in austenitic stainless steel can render this material susceptible to stress corrosion cracking, control must be exerted by the applicant, by placing an upper limit on the yield strength, in accordance with the acceptance criteria discussed in Subsection II.4.B of this SRP section. Verification is obtained that the applicant has such a control measure.

For BWRs, particular review emphasis is placed upon verification of conformance to the positions of Generic Letter 88-01 or the recommendations of NUREG-0313, Revision 2 as applicable.

C. The information submitted by the applicant is reviewed to determine the type of insulation used and to determine its compatibility with the austenitic stainless steel used in construction of the component.

There are no compatibility concerns with the use of reflective metal insulation; the chief compatibility concern is with the use of nonmetallic insulation. A review is performed to assure that any such material specified by the applicant is in conformance with the acceptance criteria stated in Subsection II.4.C of this SRP section. Verification is obtained that the material has been chemically analyzed by methods equivalent to those prescribed in Regulatory Guide 1.36 and that evidence is obtained that the levels of leachable contaminants are such that stress corrosion of stainless steel will not result from use of the insulation.

D. The information submitted by the applicant regarding control of delta ferrite in austenitic stainless steel welds is reviewed to determine its conformance with the acceptance criteria stated in Subsection II.4.D of this SRP section. The reviewer verifies that appropriate filler metal acceptance tests have been conducted and that a certified materials test report has been received. The reviewer also verifies that the applicant's program is in compliance with the staff positions in Regulatory Guide 1.31 and the more stringent criteria specified in II.4.D where applicable.

The information submitted by the applicant regarding control of electroslag weld properties for austenitic stainless steel materials is reviewed for conformance with the acceptance criteria discussed in Subsection II.4.D of this SRP section.

The review of information on the control of electroslag weld properties in austenitic stainless steels is essentially the same as that discussed previously for ferritic steels. However, because electroslag-welded austenitic stainless steels have very high impact resistance, the checks are: (1) a macroetch test is used to provide assurance that the solidification pattern is in accordance with the requirement of the acceptance criteria shown in Subsection II.4.D of this SRP section, and (2) wrought stainless steel parts are solution heat treated after welding.

The review procedure for information submitted on welder qualification for limited accessibility areas, applicable to austenitic stainless steels, is the same as that for ferritic steels, which has been discussed previously under Subsection III.3.B.(3) of this SRP section.

E. The procedures for review of nondestructive examination of tubular products fabricated from austenitic stainless steel are the same as those discussed for similar ferritic products in Subsection III.3.C of this SRP section, and the acceptance criteria are as shown in Subsection II.4.E of this SRP section.

F. Cast austenitic stainless steel is susceptible to thermal aging at reactor coolant temperatures. The reviewer verifies that the applicant has considered alternative materials to cast stainless steel and has limited use of cast stainless steel in the RCPB to those specific applications where demonstrated to be the best material selection alternative. Where cast material is used, the range of temperatures to which the material will be exposed and the ferrite content of the material receive particular review emphasis. The reviewer verifies that the applicant's proposed material specifications and fabrication controls ensure adequate fracture toughness over the design life of the plant.

Where cast austenitic stainless steel components with welded joints requiring preservice and inservice inspection are proposed, the reviewer confirms the inspectability of the welded joints using ultrasonic techniques.

5. General. If the information contained in the safety analysis reports 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 applicable acceptance criteria.

Operational Programs. The reviewer verifies that the Inservice Inspection and Inservice Testing Programs are fully described and that implementation milestones have been identified. The reviewer verifies that the program and implementation milestones are included in FSAR Table 13.x.

Implementation of this program will be inspected in accordance with NRC Inspection Manual Chapter IMC-2504, “Construction Inspection Program - Non-ITAAC Inspections.”

For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

## IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

> In sum, the materials used for construction of components of the reactor coolant pressure boundary (RCPB) have been identified by specification and found to be in conformance with the requirements of Section III of the ASME Code, and [for BWRs only] in conformance with the staff positions of Generic Letter 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping," which are based upon the technical information and/or recommendations provided in NUREG-0313, Revision 2, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping." Compliance with the above provisions for material specifications satisfies the quality standards requirements of GDC 1, GDC 30, and § 50.55a.
>
> The materials of construction of the RCPB exposed to the reactor coolant have been identified and all of the materials are compatible with the primary coolant water, which is chemically controlled in accordance with appropriate technical specifications. This compatibility has been proven by extensive testing and satisfactory performance. This includes conformance with the positions of Regulatory Guide 1.44, "Control of Sensitized Stainless Steel," and [for BWRs only] conformance with the staff positions of Generic Letter 88-01 which are based upon the technical information and recommendations provided in NUREG-0313, Revision 2. The cast austenitic stainless steels and nickel-chromium-iron alloys to be used as RCPB materials have also been demonstrated to be compatible with reactor coolant under the anticipated environmental conditions of RCPB service. General corrosion of all materials, except unclad carbon and low alloy steel, will be negligible. For these materials, conservative corrosion allowances have been provided for all exposed surfaces in accordance with the requirements of the Code, Section III. Accordingly, all RCPB materials are compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, as required by GDC 4.

The materials of construction for the RCPB are compatible with the thermal insulation used in these areas and are in conformance with the recommendations of Regulatory Guide 1.36, “Nonmetallic Thermal Insulation for Austenitic Stainless Steels.” Conformance with the above recommendations satisfies the requirements of GDC 14 and GDC 31 that the probability of rapidly propagating failure of RCPB materials be extremely low, and the probability of rapidly propagating fracture of RCPB materials be minimized.

The ferritic steel tubular products and the tubular products fabricated from austenitic stainless steel have been found to be acceptable by nondestructive examinations in accordance with the provisions of the ASME Code, Section III. Compliance with these Code requirements satisfies the quality standards requirements of GDC 1, GDC 30 and 10 CFR 50.55a for these materials.

The fracture toughness tests required by the ASME Code, augmented by Appendix G to 10 CFR Part 50, provide reasonable assurance that adequate safety margins against nonductile behavior or rapidly propagating fracture can be established for all pressure retaining components of the reactor coolant pressure boundary. The use of Appendix G of the ASME Code, Section III, and the results of fracture toughness tests performed in accordance with the Code and NRC regulations in establishing safe operating procedures, provide adequate safety margins during operating, testing, maintenance, and postulated accident conditions. Compliance with these Code provisions and NRC regulations satisfies the requirements of GDC 14 and GDC 31 that the probability of rapidly propagating failure of RCPB materials be extremely low, and the probability of rapidly propagating fracture of RCPB materials be minimized.

The controls imposed on welding preheat temperatures for welding ferritic steels are in conformance with the recommendations of Regulatory Guide 1.50, “Control of Preheat Temperature for Welding Low Alloy Steel.” These controls provide reasonable assurance that cracking of components made from low alloy steels will not occur during fabrication and minimize the possibility of subsequent cracking due to residual stresses being retained in the weldment. These controls satisfy the quality standards requirements of GDC 1, GDC 30, and § 50.55a for these materials under the specified conditions.

The controls imposed on electroslag welding of ferritic steels are in accordance with the recommendations of Regulatory Guide 1.34, “Control of Electroslag Weld Properties,” and provide assurance that welds fabricated by the process will have high integrity and will have a sufficient degree of toughness to furnish adequate safety margins during operating, testing, maintenance, and postulated accident conditions. Conformance with the recommendations of Regulatory Guide 1.34 also satisfies the quality standards requirements of GDC 1, GDC 30, and § 50.55a for these materials under the specified conditions.

The controls imposed on welding ferritic steels under conditions of limited accessibility are in accordance with the recommendations of Regulatory Guide 1.71, “Welder Qualification for Areas of Limited Accessibility,” and provide assurance that proper requalification of welders will be required in accordance with the welding conditions. These controls also satisfy the quality standards requirements of GDC 1, GDC 50, and § 50.55a for welding of ferrite materials under limited accessibility. The controls imposed on weld cladding of low-alloy steel components by austenitic stainless steel are in accordance with the recommendations of Regulatory Guide 1.43, “Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components.”  These controls provide assurance that practices that could result in underclad cracking will be restricted.  The controls also satisfy the quality standards requirements of GDC 1, GDC 30, and § 50.55a for weld cladding of low alloy steel components by austenitic stainless steel.

The controls to avoid stress corrosion cracking in reactor coolant pressure boundary components constructed of austenitic stainless steels limit yield strength of cold-worked austenitic stainless steels to 620 MPa (90,000 psi) maximum and conform to the recommendations of Regulatory Guides 1.44, “Control of the Use of Sensitized Stainless Steel,” and [for BWRs only] the positions of Generic Letter 88-01 or recommendations contained in NUREG-0313, Revision 2, and Regulatory Guide 1.37, “Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water Cooled Nuclear Power Plants.”  The controls in accordance with these recommendations are followed during material selection, fabrication, examination, and protection, in order to prevent excessive yield strength, sensitization, and contamination.  These controls provide reasonable assurance that the RCPB components of austenitic stainless steels will be in a metallurgical condition that minimizes susceptibility to stress corrosion cracking during service.  Accordingly, these controls ensure that austenitic stainless steel RCPB components are compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, as required by GDC 4.  For the same reasons, these controls meet the requirements of GDC 14 that the RCPB have an extremely low probability of abnormal leakage and rapidly propagating failure.

The controls imposed during welding of austenitic stainless steels in the RCPB are in accordance with the recommendations of Regulatory Guide 1.31, “Control of Ferrite Content in Stainless Steel Weld Metal”; [for BWRs only] the positions of Generic Letter 88-01 and/or the recommendations of NUREG-0313, Revision 2; Regulatory Guide 1.34; and Regulatory Guide 1.71.  These controls provide reasonable assurance that welded components of austenitic stainless steel will not develop microfissures during welding and will have high structural integrity.  Accordingly, these controls meet the quality standards requirements of GDC 1, GDC 30, and § 50.55a for welding of austenitic stainless steels in the RCPB, and, with respect to such welding, satisfy the requirements of GDC 14 that the RCPB have an extremely low probability of abnormal leakage and rapidly propagating failure.

The fabrication controls for cast austenitic stainless steel components, in conjunction with acceptable base material and weld metal specifications, provide for welded joint inspectability and adequate fracture toughness to resist thermal aging for the design life. Accordingly, these controls therefore satisfy the applicable requirements of GDC 1, GDC 4, GDC 14, GDC 30, and § 50.55a for these RCPB materials.

Accordingly, the staff concludes that the RCPB materials are acceptable and meet the requirements of General Design Criteria 1, 4, 14, 30, and 31 of Appendix A of 10 CFR Part 50; the requirements of Appendices B and G of 10 CFR Part 50; and the requirements of 10 CFR 50.55a of 10 CFR Part 50.

The applicant described the Inservice Inspection and Inservice Testing Programs and its implementation in conformance with 10 CFR 50.55a(g) and 10 CFR 50 Appendix A.”

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

## V. IMPLEMENTATION

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

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications submitted six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced Regulatory Guides. Acceptable repairs and upgrades are described in the referenced Generic Letter for previously accepted materials and welds which do not meet NUREG-0313, Revision 2, recommendations related to material specifications and post weld treatments for stress corrosion cracking resistant piping installations. NUREG-0313, Revision 2, recommendations for stress corrosion cracking resistant installations will be used by the staff for evaluation of susceptible piping in new BWR applications.

## 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 Power Plants," Criterion 1, "Quality Standards and Records."

3. 10 CFR Part 50, Appendix A, Criterion 4, "Environmental and Dynamic Effects Design Bases."

4. 10 CFR Part 50, Appendix A, Criterion 14, "Reactor Coolant Pressure Boundary."

5. 10 CFR Part 50, Appendix A, Criterion 30, "Quality of Reactor Coolant Pressure Boundary."

6. 10 CFR Part 50, Appendix A, Criterion 31, "Fracture Prevention of Reactor Coolant Pressure Boundary."

7. 10 CFR Part 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” Criterion XIII, “Handling, Storage and Shipping.”

8. 10 CFR Part 50, Appendix G, “Fracture Toughness Requirements.”

9. Regulatory Guide 1.31, “Control of Ferrite Content in Stainless Steel Weld Metal.”

10. Regulatory Guide 1.34, “Control of Electroslag Weld Properties.”

11. Regulatory Guide 1.36, “Nonmetallic Thermal Insulation for Austenitic Stainless Steel.”

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

13. Regulatory Guide 1.43, “Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components.”

14. Regulatory Guide 1.44, “Control of the Use of Sensitized Stainless Steel.”

15. Regulatory Guide 1.50, “Control of Preheat Temperature for Welding of Low-Alloy Steel.”

16. Regulatory Guide 1.71, “Welder Qualification for Areas of Limited Accessibility.”

17. Regulatory Guide 1.84, “Design, Fabrication, and Materials Code Case Acceptability, ASME Section III.”

18. NUREG-0313; Revision 2; “Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping”; Hazelton, W.S., Koo, W.H.; Division of Engineering and Systems Technology; January, 1988. (Revision 0 of this document replaced Branch Technical Position MTEB 5-7, “Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping,” which was a part of Revision 1 of this SRP section)

19. NRC Letter to All Licensees of Operating Boiling Water Reactors (BWRs), and Holders of Construction Permits for BWRs, “NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping (Generic Letter No. 88-01),” January 25, 1988.

20. NUREG/CR-4513 (ANL-90/42), “Estimation of Fracture Toughness of Cast Stainless Steels During Thermal Aging in LWR Systems,” Chopra, O. K., prepared by Argonne National Laboratory for the U.S. Nuclear Regulatory Commission, June 1991.

21. ASME Boiler and Pressure Vessel Code, Section II, “Materials,” Parts A, B, and C; Section III, “Rules for Construction of Nuclear Facility Components”; and Section IX, “Welding and Brazing Qualifications”; American Society of Mechanical Engineers.

22. ASTM, A-262-1970, “Detecting Susceptibility to Intergranular Attack in Stainless Steels”; Practice A “Oxalic Acid Etch Test for Classification of Etch Structures of Stainless Steels”; Practice E, “Copper-Copper Sulfate-Sulfuric Acid Test for Detecting Susceptibility to

Intergranular Attack in Stainless Steels”; Annual Book of ASTM Standards, American Society for Testing and Materials.

23. ASTM A-708-1974, “Detection of Susceptibility to Intergranular Corrosion in Severely Sensitized Austenitic Stainless Steel,” 1979 Annual Book of ASTM Standards, American Society for Testing and Materials.

24. NUREG-1823, “U.S. Plant Experience with Alloy 600 Cracking and Boric Acid Corrosion of Light-Water Reactor Pressure Vessel Materials,” U.S. Nuclear Regulatory Commission, Washington, DC, April 2005.

25. NRC Letter to All Licensees of Pressurized Water Reactors (PWRs), “Degradation of Control Rod Drive Mechanism Nozzle and Other Vessel Closure Head Penetrations” (Generic Letter 97-01), April 1, 1997.

26. NRC Order EA-03-009, “Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors,” U.S. Nuclear Regulatory Commission, Washington, DC, February 11, 2003.

27. NRC Order EA-03-009, Revision 1: “Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors,” U.S. Nuclear Regulatory Commission, Washington, DC, February 20, 2004.

28. NRC Inspection Manual Chapter IMC-2504, “Construction Inspection Program - Non-ITAAC Inspections,” issued April 25, 2006.