NUREG-0800

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

6.1.1 ENGINEERED SAFETY FEATURES MATERIALS

REVIEW RESPONSIBILITIES

Primary - Organization responsible for review of component integrity issues related to engineered safety features

Secondary - None

I. AREAS OF REVIEW

Engineered safety features (ESF) are provided in nuclear plants to mitigate the consequences of design-basis or loss-of-coolant accidents, even though the occurrence of these accidents is very unlikely. The Commission regulations of 10 CFR Part 50 require that certain systems be provided to serve as ESF systems. The fluids used in ESF systems, when interacting with the reactor coolant pressure boundary (RCPB), should have a low probability of causing abnormal leakage, of rapidly propagating failure, and of gross rupture. Containment systems, residual heat removal systems, emergency core cooling systems, containment heat removal systems, containment atmosphere cleanup systems, and certain cooling water systems are typical of the systems that are required to be provided as ESF. The materials and fluids compatibility for these systems are reviewed in this standard review plan (SRP) section. The General Design Criteria (GDC) establish functional requirements for specific systems. Specific acceptance criteria identified in subsection II of this SRP section establish the basis for acceptance of materials and fluids compatibility of the ESF systems.

USNRC STANDARD REVIEW PLAN

This Standard Review Plan, NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC's regulations. The Standard Review Plan 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 an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of Regulatory Guide 1.70 have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) are based on Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to NRR_SRP@nrc.gov.

Requests for single copies of SRP sections (which may be reproduced) should be made to the U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Reproduction and Distribution Services Section, or by fax to (301) 415-2289; or by email to DISTRIBUTION@nrc.gov. Electronic copies of this section are available through the NRC's public Web site at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/, or in the NRC's Agencywide Documents Access and Management System (ADAMS), at http://www.nrc.gov/reading-rm/adams.html, under Accession # ML063190010.

The emergency core cooling system, the containment heat removal system, the containment cleanup systems, and other ESF systems are described in the safety analysis report (SAR) and are reviewed in accordance with the SRP sections for the individual systems. The fluids compatibility and materials for these systems are reviewed in this SRP section. Auxiliary systems that directly support the ESF systems include systems such as the component cooling water (CCW), station service water (SSW), and ESF ventilation. The fluid and material compatibility of these systems are reviewed in this SRP section upon request of the responsible staff.

The specific areas of review are as follows:

1. Materials and Fabrication. The review includes the materials and fabrication procedures used in the construction of engineered safety features. The specific areas of review and review procedures are similar to those in SRP Section 5.2.3, "Reactor Coolant Pressure Boundary Materials," and SRP Section 10.3.6, "Steam and Feedwater System Materials." The purpose of the review is to assure compatibility of the materials with the specific fluids to which the materials are subjected. The review is performed to assure compliance with the applicable Commission regulations of 10 CFR Part 50, including the applicable general design criteria; the positions of applicable regulatory guides and branch technical positions, and the applicable provisions of the ASME Boiler and Pressure Vessel Code (hereinafter "the Code"), including Section II, Parts A, B, and C, Section III, Divisions 1 and 2, and Section IX. Areas that are reviewed include mechanical properties of materials (including fracture toughness), use of cold worked stainless steels, control of ferrite content in austenitic stainless steel welds, and control of ferritic steel welding.

2. Composition and Compatibility of ESF Fluids. The composition of the containment and core spray coolants must be controlled to ensure their compatibility with materials in the containment building, including the reactor vessel, reactor internals, piping, and structural and insulating materials. The methods and procedures to control the chemical composition of solutions recirculated within the containment after design-basis accidents (DBA) must be selected (a) to maintain the integrity of the RCPB, by preventing stress corrosion cracking of safety-related components, (b) to insure that adequate solution mixing of ESF fluids will occur, and (c) to prevent evolution of excessive amounts of hydrogen within the containment in the unlikely event of a design-basis accident.

   The time-dependent analysis of the pH of the fluids, including the source and quantity of all soluble acids and bases in the containment after a DBA, is reviewed.

   The controls on contaminants, such as chlorides, lead, zinc, sulfur, or mercury, in the ESF fluids are reviewed.

3. Component and Systems Cleaning. The review includes the requirements for the cleaning (in-shop and onsite) of materials and components, cleanliness control, and preoperational system cleaning and the procedures for layup of nuclear plant fluid systems. Requirements for the maintenance of system cleanliness of fluid systems and associated components during the operational phase of the nuclear power plant are also reviewed.

4. <u>Thermal Insulation</u>. The review includes the composition of the nonmetallic insulation and the control of leachable contaminants from the insulation. Nonmetallic thermal insulation that will be exposed to ESF fluids in DBA environments is evaluated as a potential source of contaminants, such as chlorides, lead, zinc, sulfur, and mercury. The review also includes the use of inhibitors to reduce the probability of stress corrosion cracking of stainless steel components.

5. <u>COL Action Items and Certification Requirements and Restrictions</u>. 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.

6. <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.

<u>Review Interfaces</u>

Other SRP sections interface with this section as follows:

1. The review of the adequacy of programs for assuring the integrity of bolting and threaded fasteners is performed under SRP Section 3.13, “Threaded Fasteners-ASME Code Class 1, 2, and 3.”

2. The evaluation of the use and compatibility of ESF fluids with organic materials (coatings) in containment, including their qualifications, is performed under SRP Section 6.1.2, “Protective Coating Systems (Paints) Organic Materials.”

3. The review of the stability of core and containment spray solutions, including solutions containing boron for reactivity control and other additives for reacting with gaseous fission products, under long-term storage and prolonged spray operating conditions, is performed under SRP Section 6.5.2, “Containment Spray as a Fission Cleanup System.”

4. The review of the acceptability of the reactor coolant chemistry and associated chemistry controls (including additives such as inhibitors) as it relates to corrosion control and compatibility with ESF materials is performed under SRP Sections 5.4.8 “Reactor Water Cleanup System (BWR),” and 9.3.4, “Chemical and Volume Control System (PWR).”

5. The review of the adequacy of the design for structural integrity of components and their supports is performed under SRP Section 3.9.3, “ASME Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures.”

6. The determination of the adequacy of post-loss-of-coolant accident (LOCA) hydrogen control, including control of the volume of hydrogen gas expected to be generated by metal-water reaction involving the fuel cladding and radiolytic decomposition of the reactor coolant, and corrosion of metals by emergency core cooling and containment spray solutions is performed under SRP Section 6.2.5, “Combustible Gas Control in Containment.”

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. GDC 1, and 10 CFR 50.55a as they relate to quality standards for design, fabrication, erection, and testing of ESF components and the identification of applicable codes and standards.

2. GDC 4 as it relates to compatibility of ESF components with environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including LOCAs .

3. GDC 14 as it relates to design, fabrication, erection, and testing of the RCPB so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

4. GDC 31 as it relates to designing the RCPB such that the boundary behaves in a nonbrittle manner and there is an extremely low probability of rapidly propagating fracture and of gross rupture of the RCPB.

5. GDC 35 as it relates to providing adequate core cooling following a LOCA at such a rate that fuel and clad damage that could inhibit core cooling is prevented and that the clad metal-water reaction is limited to negligible amounts.

6. GDC 41 as it relates to control of the concentration of hydrogen in the containment atmosphere following postulated accidents to assure that containment integrity is maintained.

7. Appendix B to 10 CFR Part 50, Criteria IX and XIII, as they relate to establishing and controlling work and inspection instructions that prescribe the special cleaning processes and measures necessary to prevent material and equipment damage or deterioration in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

8. 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.

9. 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. Materials and Fabrication. To meet the requirements of GDC 1 and 10 CFR 50.55a to assure that SSCs important to safety shall are designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed, codes and standards should be identified and records maintained. The materials specified for use in these systems must be as given in Parts A, B and C of Section II of the ASME Code and Appendix I to Section III, Division 1 of the Code.

   Regulatory Guide (RG) 1.84 describes acceptable Code Cases that may be used in conjunction with the above specifications. Fracture toughness of the materials should be as stated in SRP Section 10.3.6, "Steam and Feedwater System Materials," subsection II.1.

   A. Austenitic Stainless Steels. To meet the requirements of GDC 4 relative to compatibility of components with environmental conditions; GDC 14 with respect to fabrication and testing of the RCBP such that there is an extremely low probability of abnormal leakage, rapidly propagating failure, and gross rupture; and the quality assurance requirements of Appendix B of 10 CFR Part 50, the following guidelines should be used:

i. RG 1.44 describes acceptable criteria for preventing intergranular corrosion of stainless steel components of the ESF. Furnace-sensitized material should not be allowed in the ESF, and methods described in this guide should be followed for testing the materials prior to fabrication, and for ensuring that no deleterious sensitization occurs during welding.

ii. RG 1.31 describes acceptable criteria for assuring the integrity of welds in austenitic stainless steel ESF components. The control of delta ferrite content of weld filler metal is specified in this guide, which sets forth an acceptable basis for delta ferrite content of weld filler metal.

iii. The controls for abrasive work on austenitic stainless steel surfaces should, at a minimum, be equivalent to the controls described in RG 1.37, position C.5 to prevent contamination, which promotes stress corrosion cracking. Tools that 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.

iv. Criteria to assure adequate resistance to intergranular stress corrosion cracking (IGSCC) for susceptible boiling water reactors (BWR) austenitic stainless steel ESF piping are described in NUREG-0313 and in Attachment A to Generic Letter (GL) 88-01. The technical bases for the positions provided in GL 88-01 are detailed in NUREG-0313. These criteria are applied to piping specified in GL 88-01. GL 88-01 and NUREG-0313 criteria used for the evaluation of initial material selection and fabrication include welding controls (e.g., delta ferrite content limits) and material specifications (e.g., carbon content specifications) that are more stringent than specified in RGs 1.31 and 1.44 and should supplant the regulatory guides to assure adequate resistance of susceptible piping to IGSCC.

B. <u>Ferritic Steel Welding</u>. To meet the requirements of GDC 1 related to general quality assurance and codes and standards; Appendix B to 10 CFR Part 50, related to control of special processes; and 10 CFR 50.55a, the following acceptance criteria for ferritic steel welding should be used:

i. The amount of minimum specified preheat must be in accordance with the recommendations of the Code, Section III, Appendix D, Article D-1000, and RG 1.50, unless an alternate procedure is justified.

ii. Moisture control on low hydrogen welding materials shall conform to the requirements of the Code, Section III, Articles NB, NC, ND-2000 and 4000, and AWS D1.1, unless alternate procedures are justified.

iii. For areas of limited accessibility, the criteria of Regulatory Guide 1.71 apply a discussed in SRP Section 10.3.6.

2. Composition and Compatibility of ESF Fluids. In meeting the requirements of GDC 4 and 41 that SSCs important to safety are designed to accommodate the effects of and to be compatible with environmental conditions associated with normal operation, maintenance, testing, and postulated accident conditions, including loss-of-coolant accidents, and to assure that the concentration of hydrogen in the containment atmosphere following postulated accidents is controlled to maintain containment integrity, hydrogen generation resulting from the corrosion of metals by containment sprays during a design-basis accident should be controlled as described in RG 1.7, position C.6.

   A. Pressurized Water Reactors (PWRs). To meet the requirements of GDC 4, 14, and 41, the composition of containment spray and core cooling water should be controlled to ensure a minimum pH of 7.0, as addressed in Branch Technical Position (BTP) 6-1, "pH for Emergency Coolant Water for PWRs." Experience has shown that maintaining the pH of borated solutions at this level will help to inhibit initiation of stress corrosion cracking of austenitic stainless steel components.

      Hydrogen generation from the corrosion of materials within containment, such as aluminum and zinc, depends upon the corrosion rate, which in turn depends upon such factors as the coolant chemistry, the coolant pH, the metal and coolant temperature, and the surface area exposed to attack by the coolant.

      The assumed corrosion rates of materials in containment should be consistent with standard corrosion rate data.

   B. Boiling Water Reactors (BWRs). To meet the requirements of GDC 4, 14, and 41, the water used in the ESF systems should be controlled to provide assurance against stress corrosion cracking of unstabilized austenitic stainless steel components. Water used for emergency core cooling systems and spray systems should be controlled to ensure the following limits:

      Conductivity $\leq$0.5 mS/m ($\leq$5 µmhos/cm) @ 25 °C

      Chloride (Cl^-) < 0.20 ppm

      pH = 5.3 to 8.6 @ 25 °C

      Hydrogen generation in BWR containments is assumed to follow the same characteristics as in pressurized water reactors (PWRs) in that the rates of hydrogen generation will rise with increasing zinc corrosion as the temperature rises, and will change with any change in pH.

3. Component and Systems Cleaning. To meet the requirements of Appendix B to 10 CFR Part 50, Criteria IX and XIII, measures should be established to control the cleaning of material and equipment in accordance with work and inspection instructions to prevent damage or deterioration.

Components and systems should be cleaned in conformance with the positions of RG 1.37.

4. Thermal Insulation. To meet the requirements of GDC 1, 14, and 31, the RCPB should be designed, fabricated, erected, and tested in conformance with the following guidelines, such that there is an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture:

    A. The composition of nonmetallic thermal insulation on ESF components should be controlled as described in RG 1.36.

    B. The use of nonmetallic insulation on nonaustenitic stainless steel components should be controlled as described in RG 1.36. Moisture dripping from wet insulation can affect austenitic stainless steel components at lower elevations.

    C. Concentrations of leachable contaminants and added inhibitors should be controlled as specified in position C.2.b and Figure 1 of RG 1.36 to reduce the probability of stress corrosion cracking of austenitic stainless steel components.

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 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. ESF functions include emergency core cooling, reactivity control, fission product containment, and heat removal to an ultimate heat sink. These functions are provided to establish, maintain, and/or protect barriers against the release of fission products. In addition, ESFs may interface with the RCPB or protect the RCPB. 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 10 CFR 50.55a and GDC 1 to the ESF 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. ESF functions include emergency core cooling, reactivity control, fission product containment, and heat removal to an ultimate heat sink. These functions are provided to establish, maintain, and/or protect barriers against the release of fission products. In addition, ESF systems may interface with the RCPB or protect the RCPB. 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 ESF materials provides assurance that degradation and/or failure of the ESFs and/or the RCPB resulting from environmental service conditions that could cause substantial reduction in the capabilities of fission product barriers 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, rapidly propagating failure, and gross rupture. ESF systems, such as emergency core cooling, reactivity control, and residual heat removal, interface with the RCPB. Application of GDC 14 assures that ESF materials are selected, fabricated, installed, and tested to provide a low probability of significant degradation and, in the extreme, gross failure of the RCPB that could cause 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 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. ESF systems may interface with the RCPB or protect the RCPB. Application of GDC 31 assures that ESF materials are selected 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. GDC 35 requires that a system be provided to transfer heat from the reactor core following any loss of reactor coolant. Appropriate selection of ESF materials and fluids can enhance the likelihood of achieving design emergency core cooling flow and heat transfer rates following a loss of reactor coolant, thereby minimizing fuel damage. Meeting GDC 35 through proper material selection assures that integrity of fission product barriers is maintained in the event of a LOCA.

6. GDC 41 requires that systems be provided to control the concentration of hydrogen in the containment atmosphere following postulated accidents to assure that containment integrity is maintained. If hydrogen gas were to accumulate in explosive concentrations inside the reactor containment, ignition or detonation of the gas could threaten or breach this fission product barrier. Containment atmosphere cleanup is an ESF function. Appropriate selection of ESF materials and fluids enhances the ability to reliably perform containment atmosphere cleanup functions, including hydrogen control. ESF materials and fluids, as well as other materials used in containment, are also selected to limit the quantity of hydrogen gas generated following postulated accidents. Application of GDC 41 thus assures that following postulated accidents, hydrogen gas will not accumulate in concentrations that could threaten or breach the containment fission product barrier.

7. Criterion IX of Appendix B to 10 CFR Part 50 requires that measures be established to assure that special processes, including welding, heat treating, and nondestructive testing, are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements. ESF functions include emergency core cooling, reactivity control, fission product containment, and heat removal to an ultimate heat sink. These functions are provided to establish, maintain, and/or protect barriers against the release of fission products. Application of special process control requirements provides assurance that implementation of special processes will not introduce conditions adverse to quality in ESF systems, including, but not limited to, damage or deterioration

of ESF and/or RCPB materials and pressure boundaries, alteration of critical material properties, acceleration of effects associated with aging, flow blockages in ESF systems, or increases in the susceptibility to failure mechanisms such as stress corrosion cracking. This reduces the likelihood of degradation and/or failure of the ESFs that could cause substantial reduction in the capabilities of fission product barriers.

Criterion XIII of Appendix B to 10 CFR Part 50 requires that measures be established to control the cleaning of material and equipment to prevent damage or deterioration. Application of cleaning requirements to the ESF 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 ESFs that could cause substantial reduction in the capabilities of fission product barriers.

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. Materials and Fabrication

   A. Material Specifications. The reviewer verifies that the materials proposed for the ESF are in conformance with Parts A, B, and C of Section II of the ASME Code, Appendix I of Section III, Division 1 of the Code, and/or with acceptable material Code Cases as identified in RG 1.84. For ESF portions of the austenitic stainless steel piping specified in GL 88-01, the reviewer verifies that materials are in conformance with staff positions on BWR materials described in Attachment A to GL 88-01 or the recommendations of NUREG-0313 for stress corrosion resistant materials.

   B. Nickel-Chromium-Iron Alloys. Operating experience has indicated that certain nickel-chromium-iron alloys (e.g., Inconel) are susceptible to cracking due to corrosion. Inconel Alloy 690 has improved corrosion resistance in comparison to Inconel Alloy 600 previously used in reactor applications. Where nickel-chromium-iron alloys are proposed for use as ESF materials, 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). Particular review emphasis is placed upon the corrosion resistance and stress corrosion cracking resistance properties of the proposed nickel-chromium-iron alloy(s).

C. Austenitic Stainless Steels. The reviewer verifies that cold-worked austenitic stainless steels used in fabrication of the ESF and associated controls for fabrication are in conformance with the criteria specified in subsection II.1.A of this SRP section, including the criteria specified for BWR piping susceptible to IGSCC in Attachment A to GL 88-01 or NUREG-0313, where applicable.

The methods of controlling sensitized stainless steel in the ESF systems are examined by the reviewer who verifies that the methods are in conformance with RG 1.44. This applies especially to the verification of nonsensitization of the materials, and to the qualification of welding procedures using ASTM A-262. If alternative methods of testing the qualification welds for degree of sensitization are proposed by the applicant, the reviewer determines if these are satisfactory, based on the degree to which the alternate methods provide the needed results. An alternate method of testing for degree of sensitization that has previously been accepted is described in SRP Section 5.2.3, subsection II.4.A.

D. Corrosion Allowances. The reviewer determines that corrosion allowances are specified for ESF materials to be exposed to process fluids and that specified allowances are supported by adequate technical bases. The reviewer verifies that specified corrosion allowances are adequate for the proposed design life of affected components and piping.

E. Fabrication Controls. The reviewer examines the methods for controlling the amount of delta ferrite in stainless steel weld deposits in accordance with RG 1.31.

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

The reviewer verifies that the controls of ferritic steel welding are in conformance with subsection II.1.B of this SRP section. The reviewer verifies that the fracture toughness of the materials is in accordance with the requirements of the Code.

2. Composition and Compatibility of ESF Fluids. The reviewer considers the composition of the spray solutions and any mixing processes that might occur during operation of the sprays.

The reviewer examines the information on the compatibility of the ESF materials of construction with the ESF fluids to verify that all materials used are compatible.

A. Pressurized Water Reactors (PWRs). The reviewer determines that the coolant spray will have a minimum pH of 7.0 and reviews the methods of ascertaining that the pH will remain above this minimum during the operation of the sprays. The reviewer examines the control of pH of such coolants to evaluate the short-term (during the mixing process) compatibility and long-term compatibility of these sprays with all safety-related components within the containment.

The reviewer examines the methods of storing the ESF fluids to determine whether deterioration will occur either by chemical instability or by corrosive attack on the storage vessel. The reviewer determines what effects such deterioration could have on the compatibility of these ESF coolants with both the ESF materials of construction and the other materials within the containment.

The reviewer further verifies that hydrogen release due to corrosion of metals by emergency core cooling and containment spray solutions is controlled in accordance with RG 1.7, position C.6.

The reviewer also compares the assigned corrosion rates of materials in containment, as stated in the SAR, with standard corrosion rate data. In accordance with the procedures in SRP Section 6.5.2, the reviewer examines the paths that the solutions would follow in the containment from sprays and emergency core cooling systems to the sump, for both injection and recirculation phases to verify that no areas accumulate very high or low pH solutions and that any assumptions regarding pH in the modeling of containment spray fission product removal are valid.

B. Boiling Water Reactors (BWRs). The reviewer verifies that the chemistry of the water used for the emergency core cooling systems and the containment spray systems is controlled to the limits given in subsection II.2.B. The reviewer further verifies that hydrogen release is controlled in accordance with RG 1.7. The reviewer also compares the assumed corrosion rates of materials in containment with standard corrosion rate data.

Where appropriate for the ESF fluid under consideration, the reviewer considers the guidelines identified as acceptable for reactor coolant in SRP Section 5.4.8.

3. Component and Systems Cleaning. The reviewer verifies that components and systems are cleaned in accordance with RG 1.37.

4. Thermal Insulation. The reviewer determines whether non-metallic thermal insulation will be used on components of the ESF. If so, the reviewer verifies that the amount of leachable impurities in the specified insulation will be within the “acceptable analysis area” of Figure 1 of RG 1.36, as discussed in subsection II.4 of this SRP section.

5. 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.

1. General Design Criteria (GDC) 1, 14, and 31, and 10 CFR 50.55a have been met with respect to assuring an extremely low probability of leakage, of rapidly propagating failure, and of gross rupture. This is demonstrated by the selection of materials for the engineered safety features (ESF) that satisfy Parts A, B, and C of Section II of the ASME Code and Appendix I of Section III, Division 1 of the Code. The fracture toughness of ferritic materials selected for the ESF systems meets Code requirements.

   The controls on the use and fabrication of austenitic stainless steel in ESF systems satisfy the positions of RG 1.31, "Control of Ferrite Content of Stainless Steel Weld Metal," and RG 1.44, "Control of the Use of Sensitized Stainless Steel." Fabrication and heat treatment practices performed in accordance with these positions provide added assurance that the probability of stress corrosion cracking will be reduced during the postulated accident time interval. For BWRs, to assure adequate resistance against intergranular stress corrosion cracking, susceptible austenitic stainless steel piping appropriately conforms with the positions of Attachment A of GL 88-01 and the recommendations of NUREG-0313, Revision 2, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping."

   Conformance with the Codes and Regulatory Guides and with the staff positions mentioned above constitutes an acceptable basis for meeting the requirements of GDC 1, 4, 14, 35, and 41; Appendix B to 10 CFR Part 50; and 10 CFR 50.55a, in which the systems are to be designed, fabricated, and erected so that the systems can perform their function as required.

2. GDC 1, 14, and 31 and Appendix B to 10 CFR Part 50 have been met with respect to assuring that the reactor coolant pressure boundary and associated auxiliary systems have an extremely low probability of leakage, of rapidly propagating failures, and of gross rupture. The controls placed on concentrations of leachable impurities in non-metallic thermal insulation used on engineered safety features components are in accordance with the positions of RG 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steels." Compliance with the positions of RG 1.36 is the basis for meeting the requirements of GDC 1, 14, and 31.

3. The requirements of GDC 4, 35, and 41 and Appendix B, 10 CFR Part 50 have been met with respect to compatibility of ESF components with environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents, since the controls on pH and chemistry of the reactor containment sprays and the emergency core cooling water following a

loss-of-coolant or design-basis accident are adequate to reduce the probability of stress corrosion cracking of the austenitic stainless steel components and welds of the engineered safety features systems in containment throughout the duration of the postulated accident to completion of cleanup.

Also, the control of the pH of the sprays and cooling water, in conjunction with controls on selection of containment materials, is in accordance with RG 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident," and provides assurance that the sprays and cooling water will not give rise to excessive hydrogen gas evolution resulting from corrosion of containment metal or cause serious deterioration of the materials in containment.

The controls placed upon component and system cleaning are in accordance with RG 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants," and provide a basis for the finding that the components and systems have been protected against damage or deterioration by contaminants as stated in the cleaning requirements of 10 CFR Part 50, Appendix B.

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 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 methods 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 that 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 IGSCC susceptible portions of ESF piping in new BWR applications.

VI. REFERENCES

1. 10 CFR 50.55a, “Codes and Standards.”

2. 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 1, “Quality Standards and Records.”

3. 10 CFR Part 50, Appendix A, GDC 4, “Environmental and Dynamic Effects Design Bases.”

4. 10 CFR Part 50, Appendix A, GDC 14, “Reactor Coolant Pressure Boundary.”

5. 10 CFR Part 50, Appendix A, GDC 31, “Fracture Prevention of Reactor Coolant Pressure Boundary.”

6. 10 CFR Part 50, Appendix A, GDC 35, Emergency Core Cooling.

7. 10 CFR Part 50, Appendix A, GDC 41, Containment Atmosphere Cleanup.”

8. 10 CFR Part 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” Criterion IX, “Control of Special Processes,” and Criterion XIII, “Handling, Storage and Shipping.”

9. Regulatory Guide (RG) 1.7, “Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident.”

10. RG 1.31, “Control of Ferrite Content in Stainless Steel Weld Metal.”

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

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

13. RG 1.44, “Control of the Use of Sensitized Steel.”

14. RG 1.50, “Control of Preheat Temperature for Welding Low-Alloy Steel.”

15. RG 1.84, “Design, Fabrication, and Materials Code Case Acceptability ASME Section III.”

16. 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 previous revisions of SRP Section 5.2.3).

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

18. Branch Technical Position 6-1, "pH for Emergency Coolant Water for PWRs."

19. ASME Boiler and Pressure Vessel Code, Section II, "Materials,"" Parts A, B, and C; Section III, "Rules for Construction of Nuclear Plant Components," Division 1, including Appendix I and Division 2; and Section IX, "Welding and Brazing Qualifications," American Society of Mechanical Engineers.

20. ASTM A-262-1970, "Detecting Susceptibility to Intergranular Attack in Stainless Steel," Annual Book of ASTM Standards, American Society for Testing and Materials; 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."

21. AWS D1.1-1981, "Structural Welding Code," American Welding Society.

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

PUBLIC PROTECTION NOTIFICATION

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.