U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

6.1.1 ENGINEERED SAFETY FEATURES MATERIALS

REVIEW RESPONSIBILITIES

Primary - ~~Materials Engineering Branch (MTEB)~~Materials and Chemical Engineering Branch (EMCB)[1]

Secondary - ~~Chemical Engineering Branch (CMEB)~~None[2]

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 General Design Criteria (GDC) 1, 4, 14, 31, 35, 41 and Appendix B of 10 CFR Part 50, and 10 CFR Part 50, §50.55a require that certain systems be provided to serve as ~~Engineered safety features (~~ESF~~)~~ systems.[3] To meet GDC 14, the fluids used in ESF systems, when interacting with the reactor coolant pressure boundary (RCPB), should have a low probability of causing abnormal leakage, rapidly propagating failure and of gross rupture.[4] Containment systems, residual heat removal systems,[5] 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.

The emergency core cooling system, the containment heat removal system, the containment cleanup systems and other ESF systems are described in Section 6 of the SAR and are reviewed

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in accordance with the SRP sections for the individual systems. The fluids compatibility and materials for these systems are reviewed in this SRP section.

The fluid and material compatibility for the auxiliary systems that directly support the ESF systems identified above, include systems such as the Component Cooling Water (CCW), Station Service Water (SSW), and ESF ventilation.[6] These systems are reviewed in this SRP section upon request of the respective primary branch.

A. ~~MTEB as primary reviewer uses the evaluations by CMEB to complete the overall review of ESF materials. MTEB~~EMCB[7] review areas include the materials and fabrication procedures used in the design of[8] 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 to those of 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 ~~stated in~~of 10 CFR Part 50, including the applicable General Design Criteria~~; and with~~ the positions of applicable Regulatory Guides and Branch Technical Positions~~,~~; and~~ also with~~ the applicable provisions of the ASME Boiler and Pressure Vessel Code (hereinafter "the Code" Reference 19), including Section II, parts A, B, and C, Section III, Divisions 1 and 2, and Section IX.[9] 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.

B. ~~CMEB~~EMCB also[10] reviews areas relating to ESF fluid chemistry, component and system cleaning, and thermal insulation used in the containment. The fluid chemistry, cleaning and insulation evaluations are ~~furnished to MTEB for~~ incorporat~~ion~~ed[11] into the final SER. These are further described as follows:

1. Composition and Compatibility of Engineered Safety Features 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 reactor coolant pressure boundary, 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 history of the pH of the fluids, including the source and quantity of all soluble acids and bases in the containment after a design basis accident, is reviewed.

~~Containment and core spray solutions must be stable under long-term storage conditions and during prolonged operation of the sprays. Some of these solutions contain boron for reactivity control and other additives for reacting with gaseous fission products. Long-term storage of these solutions are reviewed under SRP Section 6.5.2 by CMEB as part of its secondary review responsibility.~~

~~In many instances the ESF coolant solutions are stored in more than one form (such as boric acid solution and a sodium hydroxide solution) and mixed only when the ESF are called upon to operate during an emergency. In some plants, the coolant is stored as a boric acid solution that is neutralized by (dry) sodium phosphates mounted in baskets inside the containment after the ESF sprays are activated.~~[12]

The controls on contaminants, such as chlorides, lead, zinc, sulfur, or mercury, in the ESF fluids are reviewed. Nonmetallic thermal insulation, that will be exposed to ESF fluids in DBA environments is evaluated as a potential source of these contaminants.

~~CMEB~~EMCB[13] reviews corrosion rates as related to hydrogen generation upon request of the ~~Containment Systems Branch (CSB)~~Containment Systems and Severe Accident Branch (SCSB).[14]

~~Compatibility of ESF fluids with organic materials (coatings) is reviewed by CMEB as part of its primary review responsibility for SRP Section 6.1.2.~~[15]

2. Component and Systems Cleaning

~~CMEB~~EMCB[16] reviews the requirements for the cleaning (shop and on-site) of materials and components, cleanliness control, and preoperational system cleaning and the procedures for lay-up 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.

3. Thermal Insulation

~~CMEB~~EMCB[17] reviews the composition of the non-metallic insulation and the control of leachable contaminants from the insulation. The branch also reviews the use of inhibitors to reduce the probability of stress corrosion cracking of automatic stainless steel components.

~~4. Coatings~~

~~CMEB reviews the use, and qualifications of the protective coatings used in containment as part of SRP Section 6.1.2. Peeling, flaking or delamination of coatings can result in clogging of ESF system strainers and spray nozzles and thereby stop or slow down the flow rates of the ESF fluids.~~[18]

Review Interfaces

EMCB also performs the following related reviews under the SRP Sections indicated:[19]

1. Reviews the adequacy of programs for assuring the integrity of bolting and threaded fasteners as part of its primary review responsibility for SRP Section 3.13 (proposed).[20]

2. Reviews the compatibility of ESF fluids with organic materials (coatings) and the use of coatings in containment, including their qualifications, as part of its primary review responsibility for SRP Section 6.1.2.[21]

3. Reviews the stability of core and containment spray solutions under long term storage and prolonged spray operating conditions, including solutions containing boron for reactivity control and other additives for reacting with gaseous fission products, as part of its primary review responsibility for SRP Section 6.5.2.[22]

4. Determines 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, as part of its primary review responsibility for SRP Sections 5.4.8 "Reactor Water Cleanup System (BWR)" and 9.3.4 "Chemical and Volume Control System (PWR)."[23]

In addition, the EMCB will coordinate other branches' evaluations that interface with the overall review of the ESF materials as follows:[24]

1. The Mechanical Engineering Branch (EMEB) determines the adequacy of the design for structural integrity of components and their supports including the adequacy of design fatigue curves for ESF materials with respect to cumulative reactor service-related environmental and usage factor effects, as part of its primary review responsibility for SRP Section 3.9.3.[25]

2. The SCSB determines 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, as part of its primary review responsibility for SRP Section 6.2.5.[26]

For those areas of review identified above as part of reviews under other SRP sections, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP sections.[27]

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in subsection I of this SRP section are based on meeting the relevant requirements of General Design Criteria (GDC) 1, 4, 14, 31, 35, 41 and Appendix B, 10 CFR Part 50, and 10 CFR Part 50, §50.55a as described below:

A. General Design Criterion 1, and 10 CFR Part 50, §50.55a~~, "Quality Standards and Records," and "Codes and Standards"~~[28] - as they relate to quality standards being used for design, fabrication, erection and testing of ESF components and the identification of applicable codes and standards.

B. General Design Criterion 4~~ "Environmental and Missile Design Bases"~~[29] - as it relates to compatibility of ESF components with environmental conditions associated with normal operation, maintenance, testing and postulated accidents, including loss-of-coolant accidents.

C. General Design Criterion 14~~, "Reactor Coolant Pressure Boundary"~~[30] - as it relates to design, fabrication, erection, and testing of the reactor coolant pressure boundary so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

D. General Design Criterion 31~~, "Fracture Prevention of Reactor Coolant Pressure Boundary"~~[31] - as it relates to extremely low probability of rapidly propagating fracture and gross rupture of the reactor coolant pressure boundary.

E. General Design Criterion 35~~. "Emergency Core Cooling"~~[32] - as it relates to assurance that core cooling is provided following a LOCA at such a rate that fuel and clad damage that could inhibit core cooling is prevented and that[33] the clad metal-water reaction is limited to negligible amounts.

F. General Design Criterion 41~~, "Containment Atmosphere Cleanup"~~[34] - as it relates to control of the concentration of hydrogen in the containment atmosphere following postulated accidents to assure that containment integrity is maintained.

G. Appendix B to 10 CFR Part 50, Criteria IX and XIII~~"Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants"~~ - as ~~it relates~~they relate to control of special processes and ~~to the requirement that~~ measures ~~be~~ established to control the cleaning of material and equipment in accordance with work and inspection instructions to prevent damage or deterioration.[35]

Specific criteria necessary to meet the relevant requirements of GDC 1, 4, 14, 31, 35, 41, ~~and~~ Appendix B to 10 CFR Part 50,[36] and 10 CFR Part 50, §50.55a for the review areas identified in subsection I of this SRP section are as follows~~.~~:[37]

~~A. Criteria for Primary Review Areas~~[38]

1. Materials and Fabrication

To meet the requirements of General Design Criterion 1 and §50.55a to assure that structures, systems and components (SSCs)[39] important to safety shall be 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

Appendix ~~1~~I[40] to Section III, Division 1[41] of the Code, and parts A, B and C of Section II of the Code.

Regulatory Guide 1.85~~, "Code Case Acceptability ASME Section III Materials,"~~[42] describes acceptable Code cases that may be used in conjunction with the above specifications. Fracture toughness of the materials shall be as stated in SRP Section 10.3.6, 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 reactor coolant pressure boundary so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture; and the quality assurance requirements of Appendix B of 10 CFR Part 50 the following guidelines should be used:

(1.)[43] Cold worked austenitic stainless steels must have a maximum 0.2% offset yield strength of 620 MPa (90,000 psi)[44] to reduce the probability of stress corrosion cracking in ESF systems.

Laboratory stress corrosion test and service experience provide the basis for this criteria.

(2.) Regulatory Guide 1.44~~, "Control of the Use of Sensitized Stainless Steel,"~~[45] 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.

(3.) ~~Branch Technical Position MTEB 5-7, "Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," describes acceptable criteria for the use of austenitic stainless steel piping in boiling water reactors. (See SRP Section 5.2.3.)~~Criteria to assure adequate resistance to intergranular stress corrosion cracking (IGSCC) for susceptible BWR austenitic stainless steel ESF piping are described in Attachment A to Generic Letter 88-01 (Reference 17) or in NUREG-0313 (Reference 16). The technical bases for the positions provided in Generic Letter 88-01 are detailed in NUREG-0313. These criteria are applied to piping specified in Generic Letter 88-01.[46] Generic Letter 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) which are more stringent than specified in Regulatory Guides 1.31 and 1.44 to assure adequate resistance of susceptible piping to IGSCC.[47]

(4.) Regulatory Guide 1.31, ~~"Control of Ferrite Content in Stainless Steel Weld Metal,"~~[48] 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.

(5) 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.[49]

b. Ferritic Steel Welding

To meet the requirements of General Design Criterion 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 Part 50, §50.55a, ~~"Codes and Standards,"~~[50] the following acceptance criteria for ferritic steel welding should be used:

(1.)[51] The amount of minimum specified preheat must be in accordance with the recommendations of the Code, Section III, Appendix D, Article D-1000, and Regulatory Guide 1.50, ~~"Control of Preheat Temperature for Welding Low-Alloy Steel,"~~[52] unless an alternate procedure is justified.

(2.) 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 (Reference 21), ~~"Structural Welding Code,"~~[53] unless alternate procedures are justified.

With respect to criteria b(1) and b(2) above, acceptable alternate procedures for ferritic steel welding are identified in SRP Section 5.2.3, subsection II.3.b.[54]

(3.) For areas of limited accessibility, the criteria of SRP Section 10.3.6, subsection II.2.~~c~~b shall apply.[55]

~~B. Criteria for Secondary Review Areas~~[56]

~~1~~2.[57] Composition and Compatibility of Engineered Safety Feature Fluids

In meeting the requirements of General Design Criteria 4 and 41, that ~~structures, systems, and components~~ SSCs[58] 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, the hydrogen generation resulting from the corrosion of metals by the containment sprays during design basis accident should be controlled as described in Regulatory Guide 1.7, position C.6., ~~"Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident."~~[59]

a. Pressurized Water Reactors (PWRs)

To meet the requirement 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 given in Branch Technical Position MTEB 6-1 which is appended to this SRP section. 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.

The 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 ~~reviewer compares the~~ assumed corrosion rates of materials in containment should be consistent with standard corrosion rate data.[60]

b. Boiling Water Reactors (BWRs)

To meet the requirements of GDC 4, 14, and 41, the water used in the engineered safety feature 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 = 0.3 to 1 mS/m (3 to 10 μmhos/cm) @ 25°C[61]

Chloride (Cl-) < 0.50 ppm

pH = 5.3 to 8.6 @ 25°C

Hydrogen generation in BWR containments is assumed to follow the same characteristics as in 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.

~~2~~3.[62] Component and Systems Cleaning

To meet the requirements of Appendix B to 10 CFR Part 50, 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 are to be cleaned in conformance with the positions of Regulatory Guide 1.37., ~~"Quality Assurance Requirements for Cleaning Fluid Systems and Associated Components of Water Cooled Nuclear Power Plants."~~[63]

~~3~~4.[64] Thermal Insulation

To meet the requirements of General Design Criteria 1, 14, and 31 so that the reactor coolant pressure boundary is designed, fabricated, erected, and tested so as to have extremely low probability of abnormal leakage, of rapidly propagating failure, and gross rupture, the following guidelines should be used:

a. The composition of nonmetallic thermal insulation for components of ESF should be controlled as described in Regulatory Guide 1.36., ~~"Nonmetallic Thermal Insulation for Austenitic Stainless Steel."~~[65]

b. The use of nonmetallic insulation on nonaustenitic stainless steel components should be controlled as above. The moisture dripping from wet insulation on any component can affect austenitic stainless steel that is at a physically lower elevation.

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

~~4. Coatings~~

~~Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Processing Plants," establishes overall quality assurance program requirements for the design, fabrication, construction, and testing of safety-related nuclear power plant structures, systems, and components.~~

~~Section IX of Appendix B relates to the control of special processes. Coating systems are deemed to fall in this category.~~

~~The qualification program for coating systems should confirm that the systems used on ESF will not possibly stop or slow down the flow rates of the ESF fluids during a design basis accident.~~

~~Identified quantities of soluble acids and bases within the containment must not be great enough to cause excessive hydrogen generation or deleterious corrosion.~~

~~The criteria for coatings to be used in containments are described in Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants."~~

~~This guide describes an acceptable means for meeting the requirements of Appendix B to 10 CFR Part 50 stated above, with regard to protective coatings applied to ferritic steels, aluminum, stainless steel, zinc-coated (galvanized steel) concrete or masonry surfaces of water cooled nuclear power plants.~~[66]

Technical Rationale[67]

The technical rationale for application of the above acceptance criteria to the ESF materials is discussed in the following paragraphs:

1. GDC 1 and 10 CFR 50.55a require that structures, systems, and components 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, of rapidly propagating failure, and of 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 which functions 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, concentrations of hydrogen gas will not accumulate which could threaten or breach the containment fission product barrier.

7. Appendix B of 10 CFR Part 50 requires, in Criterion IX, 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 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.

Appendix B of 10 CFR Part 50 also requires, in Criterion XIII, that measures be established to control the cleaning of material and equipment to prevent damage or

deterioration. 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 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 and emphasize material from the procedures described below, as may be appropriate for a particular case.

To ascertain that the acceptance criteria given in subsection II of this SRP ~~s~~Section[68] are met, the reviewer examines each of the review areas given in subsection I of this SRP section for the required information, using the following procedure:

A. ~~Primary Review Area~~Materials and Fabrication[69]

1. Material Specifications

The ~~MTEB~~[70]reviewer verifies that the materials proposed for the ESF are in conformance with Appendix I of Section III, Division 1[71] of the Code, ~~and~~ with parts A, B, and C of Section II of the Code~~.~~, and/or with acceptable material Code Cases as identified in Regulatory Guide 1.85.[72] For ESF portions of the austenitic stainless steel piping specified in Generic Letter 88-01, the reviewer verifies that materials are in conformance with staff positions on BWR materials described in Attachment A to Generic Letter 88-01 or the recommendations of NUREG-0313 for stress corrosion resistant materials.[73]

2. 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 690 alloy 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).[74]

3. Austenitic Stainless Steels

~~He~~The reviewer[75] 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.~~A.~~1.a[76] of this SRP section, including the criteria specified for BWR piping susceptible to IGSCC in Attachment A to Generic Letter 88-01 or NUREG-0313, where applicable.[77]

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 Regulatory Guide 1.44. This applies especially to the verification of nonsensitization of the materials, and to the qualification of welding procedures using ASTM A-262 (Reference 20).[78] 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 which has previously been accepted is described in SRP Section 5.2.3, subsection II.4.a.[79]

4. 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.[80]

5. Fabrication Controls

The methods for controlling the amount of delta ferrite in stainless steel weld deposits are examined by the ~~MTEB~~[81] reviewer in accordance with Regulatory Guide 1.31.~~, "Control of Ferrite Content in Stainless Steel Weld Metal."~~[82]

The applicant's description of abrasive work controls for austenitic stainless steel surfaces is reviewed and is verified adequate to minimize the cold-working of surfaces and the introduction of stress corrosion cracking promoting contaminants.[83]

The reviewer verifies that the controls of ferritic steel welding are in conformance with subsection II.~~A.~~1.b[84] of this SRP section. The reviewer verifies that the fracture toughness of the materials is in accordance with the requirements of the Code.

B. ~~Secondary Review Area~~Process Fluids and Compatibility[85]

1. Composition and Compatibility of Engineered Safety Features Fluids

The reviewer ~~(CMEB)~~[86] considers the composition of the spray solutions and any mixing processes that might occur during operation of the sprays.

The reviewer ~~(CMEB)~~[87] examines the information on the compatibility of the ESF materials of construction with the ESF fluids to verify that all materials used are compatible.

The reviewer ~~(CMEB)~~[88] verifies that components and systems are cleaned in accordance with Regulatory Guide 1.37.

The reviewer ~~(CMEB)~~[89] determines whether non-metallic thermal insulation will be used on components of the ESF, and if it is, the reviewer verifies that the amount of leachable impurities in the specified insulation will be within the "acceptable analysis area" of Figure 1 of Regulatory Guide 1.36, as discussed in subsection II.~~B.3~~4[90] of this SRP section.

~~The reviewer (CMEB) verifies that the coatings used in the containment conform with Regulatory Guide 1.54.~~[91]

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.

~~CMEB~~The reviewer[92] further verifies that hydrogen release due to corrosion of metals by emergency core cooling and containment spray solutions is controlled in accordance with Regulatory Guide 1.7, position C.6.[93]

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.~~8~~2,[94] 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.~~B.1~~2.b.[95] The reviewer further verifies that hydrogen release is controlled in accordance with Regulatory Guide 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.[96]

2. Compatibility with Other Process Fluids

The reviewer considers the composition of other process fluids to which ESF materials may be routinely exposed and the environmental conditions of exposure (e.g., temperature). The reviewer examines the information on the compatibility of the ESF materials of construction with the process fluids, including reactor coolant, to verify that all materials used are compatible. The reviewer coordinates this review with the review of compatibility and controls/limits for reactor coolant described in SRP Sections 5.4.8 and 9.3.4.[97]

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[98]

IV. EVALUATION FINDINGS

The staff concludes that the engineered safety features materials specified are acceptable and meet the requirements of GDC 1, 4, 14, 31, 35, and 41 of Appendix A of 10 CFR Part 50; Appendix B of 10 CFR Part 50, and 10 CFR Part 50, §50.55a. This conclusion is based on the following:

1. General Design Criteria 1, 14, and 31, and 10 CFR Part 50, §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 shown since the materials selected for the engineered safety features satisfy Appendix I of Section III, Division 1[99] of the ASME Code, and Parts A, B, and C of Section II of the Code, and the staff position that the yield strength of cold-worked stainless steels shall be less than 620 MPa (90,000 psi).[100] Fracture toughness of the ferritic materials meets the requirements of the Code.

   The controls on the use and fabrication of the austenitic stainless steel of the systems satisfy the ~~requirements~~positions[101] of Regulatory Guide 1.31, "Control of Ferrite

Content of Stainless Steel Weld Metal," and Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel." Fabrication and heat treatment practices performed in accordance with these ~~requirements~~positions[102] 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 Generic Letter 88-01 or the recommendations of NUREG-0313, Revision 2, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping."[103]

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

2. General Design Criteria 1, 14, and 31 and Appendix B to 10 CFR Part 50 have been met with respect to assuring that the reactor coolant pressure[104] 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 components of the Engineered Safety Features are in accordance with the ~~requirements~~positions of Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steels." Compliance with the ~~requirements~~positions of Regulatory Guide 1.36 form a basis for meeting the requirements of GDC 1, 14 and 31.[105]

~~The protective coating systems have been qualified by tests acceptable to the staff. This qualification provides reasonable assurance that the coating systems will not degrade the operation of the ESF by delaminating, flaking or peeling.~~

~~The coatings applied are in accordance with Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants."~~

~~Conformance with this Regulatory Guide provides a basis for meeting the requirements of Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants."~~[106]

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 the 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.[107]

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 Regulatory Guide 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 Regulatory Guide 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 Appendix B, 10 CFR Part 50.

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP Section.[108]

V. IMPLEMENTATION

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

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[109] Except in those cases in which the applicant proposes an acceptable alternate method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.[110]

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.[111]

Implementation schedules for conformance to parts of the methods discussed herein are contained in the referenced Rregulatory Gguides.[112] 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 IGSCC susceptible portions of ESF piping in new BWR applications.[113]

VI. REFERENCES

~~1. 10 CFR Part 50, Appendix A, "General Design Criteria," and Appendix B, "Quality Assurance Requirements for Nuclear Power Plants and Fuel Reprocessing Plants."~~[114]

1. 10 CFR Part 50, Section 50.55a, "Codes and Standards."[115]

2. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standards and Records."

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

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

5. 10 CFR Part 50, Appendix A, General Design Criterion 31, "Fracture Prevention of Reactor Coolant Pressure Boundary."

6. 10 CFR Part 50, Appendix A, General Design Criterion 35. "Emergency Core Cooling."

7. 10 CFR Part 50, Appendix A, General Design Criterion 41, "Containment Atmosphere Cleanup."[116]

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."[117]

~~5~~9. Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident."

~~6~~10. Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal."

~~7~~11. Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel."

~~8~~12. Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants."

~~9~~13. Regulatory Guide 1.44, "Control of the Use of Sensitized Steel."

~~10~~14. Regulatory Guide 1.50, "Control of Preheat Temperature for Welding Low-Alloy Steel."

~~11. Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants."[118]~~

15. Regulatory Guide 1.85, "Materials Code Case Acceptability ASME Section III Division 1."[119]

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)[120]

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 No. 88-01)," January 25, 1988.[121]

~~12. Standard Review Plan Section 3.11, Appendix, "Chemical and Radiological Environment in Containment During Postulated Accidents."~~

~~13. Standard Review Plan Section 5.2.3, "Reactor Coolant Pressure Boundary Materials."~~

~~14. Standard Review Plan Section 6.2.5, "Combustible Gas Control in Containment."~~

~~15. Standard Review Plan Section 6.5.2, "Containment Spray as a Fission Product Cleanup System."~~

~~16. Standard Review Plan Section 10.3.6, "Steam and Feedwater Systems Materials."~~

~~17. Branch Technical Position MTEB 5-7, "Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping" (attached to SRP Section 5.2.3).~~[122]

~~18~~18. Branch Technical Position MTEB 6-1, "pH for Emergency Coolant Water For PWRs," attached to this SRP section.

~~2~~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~~, Section III,~~and Division 2~~,~~; and Section IX, "Welding and Brazing Qualifications"; American Society of Mechanical Engineers.[123]

~~20~~3. ASTM A-262-1970[124], "Detecting Susceptibility to Intergranular Attack in Stainless Steel," Annual Book of ASTM Standards, ~~Part 3,~~ 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."[125]

~~21~~4. AWS D1.1-1981[126], "Structural Welding Code," American Welding Society.[127]

BRANCH TECHNICAL POSITION MTEB 6-1
(Currently the responsibility of
the Materials and Chemical Engineering Branch (EMCB))[128]

pH FOR EMERGENCY COOLANT WATER FOR PWRs

A. Background

To establish the minimum value of pH in post-accident containment sprays in pressurized water reactors, the ~~Chemical Engineering Branch~~ NRC Staff[129] has reviewed the available information and recommended the criteria listed in the Branch Technical Position below.

The minimum pH value of 7.0 follows from the Westinghouse report (Ref~~.~~erence 1)[130] conclusion that, in ECCS solutions adjusted with NaOH to pH 7.0* or greater, no cracking should be observed at chloride concentrations up to 1000 ppm during the time of interest. Figure 7 of the Westinghouse report shows that the time for initiation of cracking of sensitized and nonsensitized U-bend specimens of Type 304 austenitic stainless steel in solutions of 7.0 pH having 100 ppm chloride was 7-1/2 months and 10 months, respectively.

The great majority of tests reported in the Oak Ridge report, Reference 2, were performed with pH of 4.5, and only two tests were conducted with pH values other than 4.5. Some cracking was observed at pH 7.5 in the sensitized 304 stainless steel U-bend specimens after 2 months exposure to pH 7.5 and chloride concentration of 200 ppm. All of the 316 stainless steel specimens showed no evidence of cracking. Considering the fact that in U-bend specimens the material was sensitized, stressed beyond yield, and plastically deformed, we conclude that the reported test conditions were much more severe than the stress conditions likely to exist in the postaccident emergency coolant systems.

We agree with the Oak Ridge conclusion that absolute freedom from failure of any complex system such as a spray system can never be guaranteed, but, by proper design, fabrication, and control of the corrosive environment, the probability of failure can be significantly reduced. Our recommended minimum pH is somewhat higher than the Oak Ridge recommendation of a minimum of 6.5.

B. Branch Technical Position

~~CMEB~~The[131] criteria for pH level of postaccident emergency coolant water to reduce the probability of stress-corrosion cracking of austenitic stainless steel components, nonsensitized or sensitized, nonstressed or stressed, are as follows:

1. Minimum pH should be 7.0.

2. For the spray water recirculated from the containment sump, the higher the pH in the 7.0 to 9.5 range, the greater the assurance that no stress corrosion cracking will occur. See

*All pH values are at 25°C.

SRP Section 6.5.2 for additional water chemistry requirements related to fission product removal.

3. If a pH greater than 7.5 is used, consideration should be given to the hydrogen generation problem from corrosion of aluminum in the containment.

C. Evaluation Findings

The controls on the pH and chemistry of the reactor containment sprays and ECCS solutions meet the staff positions on postaccident chemistry requirements for PWR emergency coolant water. It also meets the requirements of GDC 14 for assuring the low probability of abnormal leakage or failure of the reactor coolant pressure boundary and safety-related structures. We conclude that the proposed pH for emergency coolant water is acceptable.

D. References

1. D. D. Whyte and L. F. Picone, "Behavior of Austenitic Stainless Steel in Post Hypothetical Loss of Coolant Environment," WCAP-7798-L, Westinghouse Nuclear Energy Systems, November 1971 (NES Proprietary Class 2).[132]

2. J. C. Griess and E. E. Creek, "Design Considerations of Reactor Containment Spray Systems - Part X, The Stress Corrosion Cracking of Types 304 and 316 Stainless Steel in Boric Acid Solutions," ORNL-TM-2412, Part X, Oak Ridge National Laboratory, May 1971.[133]

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SRP Draft Section 6.1.1
Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name, abbreviation, and responsibility for SRP Section 6.1.1.
2.	Current PRB names and abbreviations	Editorial change made to reflect current SRP Section 6.1.1 review assignments. Currently, no branch is designated as the responsible secondary review branch for SRP Section 6.1.1.
3.	Editorial	Modified to refer to an abbreviation (ESF) which is previously introduced rather than spell out and repeat identification of the abbreviation.
4.	Editorial	Added punctuation to improve the clarity of this otherwise awkward sentence. Also established abbreviation for reactor coolant pressure boundary at the point of first use.
5.	Editorial	Provided plural to reflect that some designs contain multiple systems with residual heat removal functions and to effect grammar improvement.
6.	Editorial	Spelled out abbreviations at their point of first use, consistent with terminology used throughout the SRP (e.g., in SRP 9.2.1 "SW" is called Station Service Water). Also added conjunction to improve grammar.
7.	Current PRB names and abbreviations	Revised to reflect the current PRB abbreviation for SRP Section 6.1.1 and to reflect that only one PRB presently conducts reviews under SRP Section 6.1.1.
8.	Editorial	Added preposition to improve grammar and clarity.
9.	Editorial	Modified to reflect the content of the SRP Section with respect to the regulations and ASME Code provisions considered during the review. The adjective "applicable" was added to clarify that not all regulations, GDC, and/or ASME Code provisions apply to reviews conducted under this SRP Section.Also added identification by reference number for the first citation of the ASME Code as required by SRP-UDP format guidance.
10.	Current PRB names and abbreviations	Revised to reflect the current PRB abbreviation for SRP Section 6.1.1 and to reflect that only one PRB presently conducts reviews under SRP Section 6.1.1.
11.	Current PRB names and abbreviations, editorial	Editorial change made to reflect the current PRB abbreviation and to reflect that only one PRB conducts reviews under SRP Section 6.1.1 and documents them in the final SER.

Item	Source	Description
12.	SRP-UDP format item, Editorial	Relocated and reformatted discussion of review issues/reviews for SRP Section 6.5.2 into Review Interfaces subsection [EMCB Review Interface (1)] consistent with SRP-UDP format guidance. Also deleted discussion of the secondary review branch responsibilities because EMCB is now the PRB for SRP Section 6.5.2.
13.	Current PRB names and abbreviations	Editorial change made to reflect current PRB abbreviation for SRP Section 6.1.1.
14.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and abbreviation for the branch which reviews containment system issues.
15.	SRP-UDP format item	Relocated and reformatted discussion of review issues/reviews for SRP Section 6.1.2 into Review Interfaces subsection [EMCB Review Interface (2)] consistent with SRP-UDP format guidance.
16.	Current PRB names and abbreviations	Editorial change made to reflect current PRB abbreviation for SRP Section 6.1.1.
17.	Current PRB names and abbreviations	Editorial change made to reflect current PRB abbreviation for SRP Section 6.1.1.
18.	SRP-UDP format item	Relocated and reformatted discussion of review issues/reviews for SRP Section 6.1.2 into Review Interfaces subsection [EMCB Review Interface (2)] consistent with SRP-UDP format guidance. Also deleted this Area of Review as redundant to SRP Section 6.1.2.
19.	SRP-UDP format item	Added Review Interface subsection of Areas of Review using numbered paragraphs to be consistent with SRP-UDP required format so that reviews performed by the SRP Section 6.1.1 PRB in other SRP Sections which are relevant to the overall review of ESF materials are detailed in their own subsection.
20.	SRP-UDP Integration of Bolting Issues, Potential Impact 8988	Added a review interface reflecting reviews of bolting and threaded fastener programs under new SRP Section 3.13.
21.	SRP-UDP format item	Relocated (from I.B.1 and I.B.4) and reformatted discussion of coatings review issues/reviews for SRP Section 6.1.2 into a Review Interface consistent with SRP-UDP format guidance.
22.	SRP-UDP format item	Relocated (from subsection I.B.1, 3rd paragraph) and reformatted discussion of ESF spray solution review issues/reviews for SRP Section 6.5.2 as a Review Interface consistent with SRP-UDP format guidance.

Item	Source	Description
23.	**Integrated Impact 341**	Added a Review Interface for review of reactor coolant chemistry controls/specifications to support review of compatibility with ESF materials.
24.	Editorial	Added sentence consistent with SRP-UDP format, to introduce Review Interfaces with other branches.
25.	Potential Impact 22181	The consistency check for PI 22181 suggests that a review interface with SRP Section 3.9.3 be considered, since the staff discussed issues associated with environmental and usage factor effects upon the fatigue resistance of materials in conjunction with reviews of ESF materials, in section 6.1.1 of the CE System 80+ FSER.
26.	**Integrated Impact 336**	Added Review Interface with SRP Section 6.2.5 to address a complete review of all post-LOCA hydrogen generation mechanisms required to be considered under 10 CFR 50.44.
27.	Editorial	Revised to reflect standard SRP-UDP discussion of the criteria and reviews detailed in other SRP Sections in Areas of Review, Review Interfaces.
28.	SRP-UDP format item, Reference Verification, Editorial	Added location (i.e. 10 CFR Part 50) of the applicable requirements of section 50.55a for clarity. Also added paragraph numbering and deleted identification of regulations by title since titles are provided in subsection VI, References.
29.	SRP-UDP format item, Editorial	Added paragraph numbering and deleted identification of regulations by title since titles are provided in subsection VI, References.
30.	SRP-UDP format item, Editorial	Added paragraph numbering and deleted identification of regulations by title since titles are provided in subsection VI, References.
31.	SRP-UDP format item, Editorial	Added paragraph numbering and deleted identification of regulations by title since titles are provided in subsection VI, References.
32.	SRP-UDP format item, Editorial	Added paragraph numbering and deleted identification of regulations by title since titles are provided in subsection VI, References.
33.	Editorial	Added discussion of further requirements of GDC 35 which are relevant (i.e. they are an underlying purpose of SRP Section 6.1.1 reviews of ESF materials).
34.	SRP-UDP format item, Editorial	Added paragraph numbering and deleted identification of regulations by title since titles are provided in subsection VI, References.

Item	Source	Description
35.	SRP-UDP format item, Reference Verification, Editorial	Added more precise location of the applicable requirements for clarity. Also added paragraph numbering and deleted identification of regulations by title since titles are provided in subsection VI, References. Since 10 CFR 50 Appendix B requirements for control of special processes are explicitly discussed in specific criterion 1.b, Acceptance Criteria was modified to reflect that these requirements are applied in SRP Section 6.1.1 reviews.
36.	Editorial	Revised to eliminate excessive use of conjunctions (e.g., "and") and for improvement of punctuation.
37.	Editorial	Revised using a more appropriate punctuation for the context.
38.	Editorial	Revised general outline/organization of specific criteria subsection to reflect that only one PRB conducts reviews under SRP Section 6.1.1.
39.	Editorial	Established "SSCs" as an abbreviation for structures, systems, and components at the point of its first use in SRP Section 6.1.1.
40.	Reference verification	Corrected citation of Code Section III Appendix citation based upon the 1989 and 1992 editions of the Code.
41.	Reference verification	Determined that Appendix I is an appendix of Section III, Division 1 of the Code in the 1989 and 1992 editions.
42.	Reference Verification, SRP-UDP format item	Deleted an obsolete title for RG 1.85. The title was deleted, rather than updated, because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format.
43.	SRP-UDP format item, Editorial	Added parenthetical numbering for clarity in the overall outline numbering scheme used in this SRP section..
44.	NRC Metrication Policy implementation	Added the SI equivalent of 90,000 psi and reformatted in SI units consistent with NRC metrication policy. See attached Metrication Documentation.
45.	Reference Verification, SRP-UDP format item	Deleted title for RG 1.44. The title was deleted because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format.
46.	**Integrated Impact 333;** Reference Verification	Replaced obsolete citation of BTP MTEB 5-7 with citations of documents providing current staff positions which supersede the BTP. Added specific criteria for review of BWR austenitic stainless steel ESF piping exposed to reactor coolant during power operation.

Item	Source	Description
47.	**Integrated Impacts 334 and 335**	Added indication that where criteria more stringent than specified in RGs 1.31 and 1.44 are necessary to assure adequate resistance to IGSCC, these more stringent criteria are applied.
48.	Reference Verification, SRP-UDP format item	Deleted title for RG 1.31. The title was deleted because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format.
49.	**Integrated Impact 346**	Added specific criteria for abrasive work on stainless steel surfaces based upon RG 1.37 position C.5 related to grinding, and staff review of the issue as described in the CE System 80+ FSER.
50.	Reference Verification, SRP-UDP format item	Deleted title for 10 CFR 50.55a. The title was deleted because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format.
51.	SRP-UDP format item, Editorial	Added parenthetical numbering for clarity in the overall outline numbering scheme used in this SRP section.
52.	Reference Verification, SRP-UDP format item	Deleted title for RG 1.50. The title was deleted because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format.
53.	Reference Verification, SRP-UDP format item	Deleted title for AWS D1.1. The title was deleted because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format. Also added identification by reference number per SRP-UDP format guidance.
54.	**Integrated Impact 1278**	Added reference to ferritic steel welding procedures explicitly identified as providing acceptable alternative controls to RG 1.50 in SRP Section 5.2.3.
55.	Editorial	Revised incorrect reference to SRP Section 10.3.6, subsection II.2.c.
56.	Editorial	Revised general outline/organization of specific criteria subsection to reflect that only one PRB conducts reviews under SRP Section 6.1.1.
57.	Editorial	Revised general outline/organization of specific criteria subsection and renumbered where necessary to reflect that only one PRB conducts reviews under SRP Section 6.1.1.
58.	Editorial	Revised to use the previously established abbreviation "SSCs" in place of structures, systems, and components.

Item	Source	Description
59.	**Integrated Impact 336,** Reference Verification, SRP-UDP format item	Deleted title for RG 1.7. The title was deleted because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format. Also specified the position in RG 1.7 which is applicable to this review.
60.	Editorial	Revised to reflect wording as criteria rather than a review procedure.
61.	NRC Metrication Policy implementation	Added the SI equivalent of 3-10 micromhos/cm and reformatted in SI units consistent with NRC metrication policy. See attached Metrication Documentation.
62.	Editorial	Revised general outline/organization of specific criteria subsection and renumbered where necessary to reflect that only one PRB conducts reviews under SRP Section 6.1.1.
63.	Reference Verification, SRP-UDP format item	Deleted title for RG 1.37. The title was deleted because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format.
64.	Editorial	Revised general outline/organization of specific criteria subsection and renumbered where necessary to reflect that only one PRB conducts reviews under SRP Section 6.1.1.
65.	Reference Verification, SRP-UDP format item	Deleted title for RG 1.36. The title was deleted because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format.
66.	Editorial, SRP-UDP format item	Deleted this criteria as redundant to criteria specified in SRP Section 6.1.2.
67.	SRP-UDP format item	Technical Rationale were developed and added for the following Acceptance Criteria: GDCs 1, 4, 14, 31, 35, and 41; 10 CFR 50 Appendix B; and 10 CFR 50.55a. The SRP-UDP program requires that Technical Rationale be developed for the Acceptance Criteria.
68.	SRP-UDP format item	Capitalized the first letter in "Section" consistent with SRP-UDP format/content guidance for citation or discussion of SRP Section(s) within the text of the SRP.
69.	Editorial	Revised general outline/organization of Review Procedures subsection to reflect that only one PRB conducts reviews under SRP Section 6.1.1. Revised title of subsection A to reflect subsection content instead of reviewer identity. Also added paragraph numbering and subsection titles for consistency with Review Procedure B.

Item	Source	Description
70.	Editorial	Deleted unnecessary identification of the PRB.
71.	Reference verification	Determined that Appendix I is an appendix of Section III, Division 1 of the Code.
72.	Editorial	Since use of acceptable Code Cases is permitted in the Acceptance Criteria (in specific criterion II.1), the Review Procedure is revised to reflect that materials conforming to Code Cases described in Regulatory Guide 1.85 are also acceptable.
73.	**Integrated Impact 333**	Added Review Procedure for review of BWR austenitic stainless steel ESF piping exposed to reactor coolant during power operation.
74.	**Integrated Impact 337**	Added Review Procedures for review of nickel-chromium-iron alloys proposed as ESF materials.
75.	Editorial	Revised to eliminate use of a gender specific pronoun.
76.	SRP-UDP format item, Editorial	Since the referenced specific criteria subsection also specifies fabrication-related criteria, review of fabrication controls was added. Also revised to reflect renumbering of specific criteria in subsection II.
77.	**Integrated Impacts 333, 334, and 335**	Added Review Procedures applicable to BWR austenitic stainless steel ESF piping exposed to reactor coolant during power operation.
78.	Editorial, SRP-UDP format item	Added dash for consistency with other citations of this standard. Also added identification by reference number for the first citation of A-262.
79.	**Integrated Impact 1280,** Reference Verification	Added reference to a method identified as a previously accepted alternative to the weld qualification/non-sensitization verification guidance of RG 1.44, in SRP Section 5.2.3.
80.	**Integrated Impact 338**	Added Review Procedures for review of corrosion allowances for ESF materials.
81.	Editorial	Deleted unnecessary identification of the PRB.
82.	Reference Verification, SRP-UDP format item	Deleted title for RG 1.31. The title was deleted because referenced document titles are normally provided in subsection VI, References under the SRP-UDP format.
83.	**Integrated Impact 346**	Added Review Procedures for review of abrasive work controls for stainless steel surfaces.
84.	Editorial	Revised to reflect renumbering of specific criteria in subsection II.

Item	Source	Description
85.	Editorial	Revised general outline/organization of Review Procedures subsection to reflect that only one PRB conducts reviews under SRP Section 6.1.1. Revised title of subsection B to reflect subsection content instead of reviewer identity.
86.	Editorial	Deleted unnecessary identification of the PRB.
87.	Editorial	Deleted unnecessary identification of the PRB.
88.	Editorial	Deleted unnecessary identification of the PRB.
89.	Editorial	Deleted unnecessary identification of the PRB.
90.	Editorial	Revised to reflect renumbering of specific criteria in subsection II.
91.	SRP-UDP format item	Deleted this review as redundant to reviews performed in SRP Section 6.1.2.
92.	Editorial	Revised to remove unnecessary identification of the PRB.
93.	**Integrated Impact 336,** Editorial	Revised to discuss and specify the position in RG 1.7 which is applicable to this review to distinguish this review from those conducted under SRP Section 6.2.5.
94.	Reference Verification, Editorial	Corrected erroneous reference to a non-existent SRP Section. Also added punctuation to improve clarity.
95.	Editorial	Revised to reflect renumbering of specific criteria in subsection II.
96.	**Integrated Impact 342**	Added Review Procedure for verification of acceptable ESF fluid chemistry.
97.	**Integrated Impact 341**	Added Review Procedure for review of ESF material compatibility with process fluids other than ESF fluids.
98.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
99.	Reference verification	Determined that Appendix I is an appendix of Section III, Division 1 of the Code in the 1989 and 1992 editions.
100.	NRC Metrication Policy implementation	Added the SI equivalent of 90,000 psi and reformatted in SI units consistent with NRC metrication policy. See attached Metrication Documentation.
101.	Editorial	Revised characterization of Regulatory Guide content as "positions" consistent with their characterization in Regulatory Guides.
102.	Editorial	Revised characterization of Regulatory Guide content as "positions" consistent with their characterization in Regulatory Guides.

Item	Source	Description
103.	**Integrated Impacts 333, 334, and 335**	Added findings for BWR austenitic stainless steel piping related to conformance with Generic Letter 88-01 positions and NUREG-0313, Revision 2 recommendations.
104.	Editorial	Revised to use standard terminology used in regulations, guidance, the SRP, etc. to describe the boundary under consideration herein.
105.	Editorial	Revised to reflect characterization of information contained in Regulatory Guides as positions rather than requirements.
106.	SRP-UDP format item	Deleted these findings as redundant to findings described in SRP Section 6.1.2.
107.	Editorial	Modified improper punctuation to improve sentence clarity.
108.	SRP-UDP Format Item, implementation of 10 CFR 52	Provided standard change to Evaluation Findings to address design certification reviews.
109.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
110.	Editorial	Added "conformance with" text similar to most Implementation discussions throughout the SRP.
111.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
112.	Editorial	Capitalized first letter for "Regulatory" and "Guide" consistent with other citations and discussions of Regulatory Guides in the SRP.
113.	SRP-UDP format item, implementation of evolutionary/new plant issues	Revised to address the approach to implementation of evolutionary plant issues in the SRP. Added explicit description of the applicability of NUREG-0313, Rev. 2 to the review of new BWR applications (rather than identifying its applicability to evolutionary BWRs in the body of the SRP section).
114.	Editorial	Deleted reference to Appendix B since it is listed as a separate reference.
115.	SRP-UDP format item	Added reference listing of 10 CFR 50.55a since it is cited as Acceptance Criteria in subsection II.
116.	SRP-UDP format item	Added reference listing of each GDC cited in subsection II as Acceptance Criteria.
117.	SRP-UDP format item	Relocated reference listing of 10 CFR 50, Appendix B and added reference to Criterion XIII since it is cited as Acceptance Criteria in subsection II.

Item	Source	Description
118.	Editorial, SRP-UDP format item	Since all citations of Regulatory Guide 1.54 in SRP Section 6.1.1 were deleted as redundant to criteria and reviews specified in SRP Section 6.1.2, reference listing of Regulatory Guide 1.54 is also deleted. Documents not cited within an SRP section should not be listed as references per SRP-UDP format.
119.	SRP-UDP format item	Added reference listing for RG 1.85 since it is cited as specific criteria in subsection II.1.
120.	**Integrated Impact 333**, Reference verification	Added reference listing of NUREG-0313, Rev. 2. Also provided historical discussion that NUREG-0313 superseded BTP MTEB 5-7.
121.	**Integrated Impact 333**	Added reference listing for Generic Letter 88-01.
122.	SRP-UDP format item, Reference verification	Deleted reference listings for other SRP Sections since they are a part of NUREG-0800 along with SRP Section 6.1.1. Also deleted obsolete reference listing of Branch Technical Position MTEB 5-7 since this BTP is superseded by NUREG-0313.
123.	Reference Verification, SRP-UDP format item	Added titles for major Code sections identified for this reference.
124.	**Integrated Impact 1446**	Added version date reflecting the latest version of the standard endorsed in Regulatory Guide 1.44.
125.	**Integrated Impact 339,** SRP-UDP standards citation update, Reference verification	Consideration should be given to updating the citation of ASTM A-262 pending the review and approval of the associated standard comparison. No change reflecting the latest version of ASTM A-262 was made. Since SRP Section 5.2.3 reflects acceptability of ASTM A-708 to the staff as an alternative to Practices A or E of ASTM A-262, added reference to ASTM A-262 Practices A and E for consistency with references for SRP Section 5.2.3.
126.	**Integrated Impact 1447**	Added version date for the standard reflecting the version in effect as of the last revision of the SRP section.
127.	**Integrated Impact 340,** Reference verification, No change	The current title of AWS D1.1 is "Structural Welding Code Steel" based on the thirteenth edition published in 1994. Since this reference is a code/standard, no change is permitted under the SRP-UDP until NRC acceptance of a standard comparison performed for the cited/latest editions.
128.	SRP-UDP format item	Added identification of current PRB responsibility for this Branch Technical Position.
129.	Current PRB names and abbreviations	Editorial change made to avoid an obsolete PRB name for SRP Section 6.1.1 and this associated BTP.

Item	Source	Description
130.	SRP-UDP format item	Spelled out "Reference" per SRP-UDP format guidance.
131.	Editorial	Revised to remove unnecessary identification of the PRB.
132.	No change, Reference Verification	Could not verify a current version for this reference.
133.	No change, Reference Verification	Could not verify a current version for this reference.

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Integrated Impact No.	Issue	SRP Subsections Affected
333	Revise the SRP to address staff positions related to avoiding IGSCC in BWR austenitic stainless steel piping, based upon NUREG-0313, Rev. 2 and Generic Letter 88-01.	Acceptance Criteria (specific criteria) subsection II.1.a.3; Review Procedures subsections III.A.1 and III.A.3; Evaluation Findings subsection IV.1; Implementation subsection V; and References subsection VI, references 16 and 17.
334	Revise the SRP to address staff positions for stainless steel weld metal which are more restrictive than RG 1.31.	Acceptance Criteria (specific criteria) subsection II.1.a.3; Review Procedures subsection III.A.3; Evaluation Findings subsection IV.1; and Implementation subsection V.
335	Revise the SRP to address staff positions, based upon NUREG-0313, Rev. 2 and Generic Letter 88-01, which are more restrictive than RG 1.44.	Acceptance Criteria (specific criteria) subsection II.1.a.3; Review Procedures subsection III.A.3; Evaluation Findings subsection IV.1; and Implementation subsection V.
336	Revise the SRP to include 10 CFR 50.44 as Acceptance Criteria for review of post-LOCA hydrogen gas evolution.	Areas of Review, Review Interface 2 (with other PRBs), Acceptance Criteria subsection II.2, Review Procedures, subsection III.B.1.a.
337	Add Review Procedures for review of the acceptability of nickel-chromium-iron alloys as RCPB materials.	Review Procedures subsection III.A.2.
338	Add Review Procedures for review of corrosion allowances for ESF materials.	Review Procedures subsection III.A.4.
339	Revise the SRP to cite the latest version of ASTM A-262. Also evaluate the latest version of ASTM A-262 for regulatory endorsement (in Regulatory Guides 1.37 and 1.44).	No changes in this proposed draft revision.
340	Evaluate the latest version of AWS D1.1 to enable update of SRP Section 6.1.1 citations.	No changes in this proposed draft revision.
341	Develop Review Procedures for review of the compatibility of ESF materials exposed to process fluids other than ESF fluids.	Areas of Review, Review Interface 3 (with other EMCB reviews); Review Procedures subsection III.B.2.
342	Revise Review Procedures for review of the composition and compatibility of ESF fluids based upon new staff positions citing EPRI reports as providing acceptable specifications.	Review Procedures subsection III.B.1.b.

343	Revise the SRP to address staff positions supplementing EPRI Evolutionary Plant Utilities Requirements Document (URD) requirements for control of impurities/contaminants to which NSSS materials could be exposed.	No changes in this proposed draft revision.
344	Revise the SRP to cite ANSI/ASME NQA-2 in addition to Regulatory Guide 1.37 for cleanliness controls. Also consider revising Regulatory Guide 1.37 to cite ANSI/ASME NQA-2.	No changes in this proposed draft revision.
345	Evaluate the latest versions of AWS A4.2 and AWS A5.4 for regulatory endorsement (in Regulatory Guide 1.31).	No changes in this proposed draft revision.
346	Revise the SRP to address staff positions related to abrasive work (e.g., grinding) on austenitic stainless steel which are more restrictive than RG 1.37.	Acceptance Criteria (specific criteria) subsection II.1.a.5; Review Procedures subsection III.A.5.
1278	Revise the SRP to address acceptable alternatives to RG 1.50.	Acceptance Criteria (specific criteria) subsection II.1.b
1280	Revise the SRP to address acceptable alternatives to RG 1.44 guidance to use ASTM A-262 Practices A or E for verification of nonsensitization.	Review Procedures subsection III.A.3.
1446	Add 1970 version date for standard ASTM A-262 citation.	References, subsection VI.20.
1447	Add 1981 version date for standard AWA D1.1 citation.	References, subsection VI.21.