NUREG-0800
(Formerly NUREG-75/087)

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)~~Organization responsible for review of component integrity issues related to engineered safety features

Secondary - ~~Chemical Engineering Branch (CMEB)~~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 Appendix A of 10 CFR Part 50, General Design Criteria (GDC) 1, 4, 14, 31, 35, and 41, and Appendix B of 10 CFR Part 50, and 10 CFR Part 50, §50.55a~~ The Commission regulations of 10 CFR Part 50 require that certain systems be provided to serve as ~~Engineered safety features (~~ESF~~)~~ systems. ~~To meet GDC 14, the~~ 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~~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.

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 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 a~~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. The fluid and material compatibility for ~~T~~these systems are reviewed in this SRP section upon request of the ~~respective~~ responsible primary branch.

The specific areas of review are as follows:

~~A~~1. Materials and Fabrication

~~MTEB as primary reviewer uses the evaluations by CMEB to complete the overall review of ESF materials. MTEBEMCB~~The review ~~areas~~ includes the materials and fabrication procedures used in the ~~design~~ 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 ~~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 ~~G~~general ~~D~~design ~~C~~criteria; ~~and with~~ the positions of applicable ~~R~~regulatory ~~G~~guides and ~~B~~branch ~~T~~technical ~~P~~positions, and ~~also with~~ the applicable provisions of the ASME Boiler and Pressure Vessel Code (hereinafter "the Code," Reference 19), including Section II, ~~p~~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.

~~B. CMEBEMCB also 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 incorporationed into the final SER. These are further described as follows:~~

~~1~~2. Composition and Compatibility of ESF ~~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~~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 ~~history~~ of the pH of the fluids, including the source and quantity of all soluble acids and bases in the containment after a DBA~~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.~~

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~~ ~~reviews corrosion rates as related to hydrogen generation upon request of the Containment Systems Branch (CSB)~~~~Containment Systems and Severe Accident Probabilistic Safety Assessment Branch (SCSB) (SPSB)~~~~.~~

~~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.~~

~~2~~3. Component and Systems Cleaning

~~CMEB~~~~EMCB~~The reviews~~s~~ includes the requirements for the cleaning (in-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~~4. Thermal Insulation

~~CMEB~~~~EMCB~~ ~~reviews~~The review includes the composition of the non-metallic 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 ~~branch also~~ reviews~~s~~ also includes 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.~~

5. Inspection, Test, Analysis, and Acceptance Criteria (ITAAC)

For design certification and combined license (COL) reviews, the applicant's proposed information on the ITAAC associated with the systems, structures, and components (SSCs) related to this SRP section is reviewed in accordance with SRP Section 14.3. It is recognized that the review of ITAAC is performed after review of the application against acceptance criteria contained in this SRP section. Furthermore, the ITAAC are reviewed to assure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP 14.3.

Review Interfaces

The listed 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."

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.

~~EMCB also performs the following related reviews under the SRP sections indicated:~~

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).~~

2. ~~Reviews the use and 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.~~

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.~~

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)."~~

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

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.~~

~~2. The SCSB SPSB 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.~~

~~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.~~

II. <u>ACCEPTANCE CRITERIA</u>

~~The a~~Acceptance criteria ~~for the areas of review described in subsection I of this SRP section~~ are based on meeting the relevant requirements of the following Commission regulations:~~General Design Criteria (GDC) 1, 4, 14, 31, 35, 41 and Appendix B, 10 CFR Part 50, 10 CFR Part 50, § 50.55a, and 10 CFR Part 52, as described below:~~

A. ~~General Design Criterion~~ GDC 1, and 10 CFR ~~Part 50,~~ §50.55a~~, "Quality Standards and Records," and "Codes and Standards" -~~ 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~~ GDC 4 ~~"Environmental and Missile Design Bases" -~~ as it relates to compatibility of ESF components with environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including LOCAs ~~loss-of-coolant accidents~~.

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

D. ~~General Design Criterion~~ GDC 31~~, "Fracture Prevention of Reactor Coolant Pressure Boundary" -~~ 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 ~~reactor coolant pressure boundary~~RCPB.

E. ~~General Design Criterion~~ GDC 35~~. "Emergency Core Cooling" -~~ as it relates to providing adequate ~~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 the clad metal-water reaction is limited to negligible amounts.

F. ~~General Design Criterion~~ GDC 41~~, "Containment Atmosphere Cleanup" -~~ 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 relatesthey 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~~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.

H. 10 CFR 52.47(a)(1)(vi), which requires ITAAC (for design certification) sufficient to assure that the SSCs in this area of review will operate in accordance with the certification.

I. 10 CFR 52.97(b)(1), which requires ITAAC (for combined licenses) sufficient to assure that the SSCs in this area of review have been constructed and will be operated in conformity with the license and the Commissions regulations.

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

~~A. Criteria for Primary Review Areas~~

1. Materials and Fabrication

To meet the requirements of ~~General Design Criterion~~ GDC 1 and ~~§~~ 10 CFR 50.55a to assure that ~~structures, systems and components~~ ~~(~~SSCs~~)~~ 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 Parts A, B and C of Section II of the ASME Code and Appendix ~~1~~I to Section III, Division 1 of the Code~~, and p~~P~~arts A, B and C of Section II of the Code~~.

Regulatory Guide 1.84~~5, "Code Case Acceptability ASME Section III Materials,"~~ describes acceptable Code ~~c~~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, "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~~reactor coolant pressure boundary so as to have~~ such that there is 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.) Cold worked austenitic stainless steels must have a maximum 0.2% offset yield strength of 620 MPa (90,000 psi) to reduce the probability of stress corrosion cracking in ESF systems.~~

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

(1~~2.~~) Regulatory Guide 1.44~~, "Control of the Use of Sensitized Stainless Steel,"~~ describes acceptable criteria for preventing intergranular corrosion of stainless steel components of the ESF. Furnace-sensitized material

[1]Note: ~~The specific SRP acceptance criteria represent an acceptable approach for meeting relevant requirements, but are not substitutes for the requirements themselves. However, applicants are required to identify differences from the SRP acceptance criteria and evaluate how the proposed alternatives to these criteria provide an acceptable method of complying with the NRC's regulations.~~ The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, applicants are required to identify differences between the design features, analytical techniques, and procedural measures proposed for their 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.

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. 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.~~

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

(3~~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 that ~~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.

(4) 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 (Reference 16) and in Attachment A to Generic Letter 88-01 (Reference 17)~~ and 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. 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) that~~which~~ are more stringent than specified in Regulatory Guides 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 General Design Criterion 1 related to general quality assurance and ~~C~~codes and ~~S~~standards~~,~~; Appendix B to 10 CFR Part 50, related to control of special processes; and 10 CFR ~~Part 50, §~~ 50.55a~~, "Codes and Standards,"~~ the following acceptance criteria for ferritic steel welding should be used:

(1~~.~~) 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,"~~ 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,"~~ 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.~~

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

~~B. Criteria for Secondary Review Areas~~

~~1~~2. Composition and Compatibility of ESF ~~Engineered Safety Feature~~ Fluids

In meeting the requirements of General Design Criteria 4 and 41~~,~~ that ~~structures, systems, and components~~ 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, ~~the~~ hydrogen generation resulting from the corrosion of metals by ~~the~~ containment sprays during a 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."~~

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 ~~given~~ in Branch Technical Position ~~MTEB~~ ~~EMCB~~ 6-1, "pH for Emergency Coolant Water for PWRs ~~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 h~~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.

b. Boiling Water Reactors (BWRs)

To meet the requirements of GDC 4, 14, and 41, the water used in the ESF ~~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~~ #0.5 mS/m (~~3 to 10~~ #5 μmhos/cm) @ 25 EC

Chloride (Cl^-) < ~~0.50~~ 0.20 ppm

pH = 5.3 to 8.6 @ 25 EC

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.

~~2~~3. <u>Component and Systems Cleaning</u>

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 ~~are to~~ should 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."~~

~~3~~4. <u>Thermal Insulation</u>

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

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

b. The use of nonmetallic insulation on nonaustenitic stainless steel components should be controlled as described in Regulatory Guide 1.36~~above~~. ~~The m~~Moisture dripping from wet insulation ~~on any component~~ can affect austenitic stainless steel components at ~~that is at a physically~~ lower elevations.

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.~~

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

~~1~~A. GDC 1 and 10 CFR 50.55a require that SSCs ~~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~~B. 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~~C. 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~~D. 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~~E. 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~~F. 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 in concentrations that ~~which~~ could threaten or breach the containment fission product barrier.

~~7~~G. Criterion IX of Appendix B ~~of~~ to 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 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 ~~of~~ to 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. <u>REVIEW PROCEDURES</u>

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

For each area of review specified in subsection I of this SRP section, the review procedure is identified below. These review procedures are based on the identified SRP acceptance criteria. For deviations from these specific acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives to the SRP criteria provide an acceptable method of complying with the relevant NRC requirements identified in subsection II.

~~To ascertain that the acceptance criteria given in subsection II of this SRP sSection 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~~1. ~~Primary Review Area~~Materials and Fabrication

~~1~~a. Material Specifications

The ~~MTEB~~reviewer verifies that the materials proposed for the ESF are in conformance ~~with Appendix I of Section III~~, ~~Division 1~~ ~~of the Code, and~~ with ~~p~~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 Regulatory Guide 1.84~~5~~. 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.

~~2~~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 ~~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).

~~3~~c. Austenitic Stainless Steels

~~He~~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.~~A.~~1.a 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.

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). 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 ~~which~~ has previously been accepted is described in SRP Section 5.2.3, subsection II.4.a.

~~4~~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.

~~5~~e. Fabrication Controls

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

The reviewer verifies 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 contaminants through stress corrosion cracking ~~promoting contaminants~~.

The reviewer verifies that the controls of ferritic steel welding are in conformance with subsection II.~~A.~~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.

~~B~~2. ~~Secondary Review Area~~~~Process Fluids and Compatibility~~ Composition and Compatibility of ESF ~~Engineered Safety Features~~ Fluids

~~1. Composition and Compatibility of ESF Engineered Safety Features Fluids~~

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

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

~~The reviewer (CMEB) determines whether non-metallic thermal insulation will be used on components of the ESF,. and iIf 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.34 of this SRP section.~~

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

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 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.

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, 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. 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.

~~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.~~

3. Component and Systems Cleaning

The reviewer verifies that components and systems are cleaned in accordance with Regulatory Guide 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 Regulatory Guide 1.36, as discussed in subsection II.4 of this SRP section.

~~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. [Strike out text above is to be removed from the document after OGC review - It was provided to show the previous language in reference to 10 CFR Part 52. The revised language in reference to 10 CFR Part 52 is given below.]~~

5. 10 CFR Part 52 Review

For reviews of COL applications under 10 CFR Part 52, the reviewer should follow the above procedures to verify that the design set forth in the safety analysis report, and if applicable, site interface requirements meet the acceptance criteria. For design certification applications, the reviewer should identify necessary combined license action items. Following this review, SRP Section 14.3 should be followed for the review of Tier I information for the design, including the postulated site parameters, interface criteria, and ITAAC. With respect to COL applications, the scope of the review is dependent on whether the COL applicant references a design certification, an~~d~~ ESP or other NRC-approved material.

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 (GDC) 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~~ demonstrated by the selection of materials ~~selected~~ 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 ~~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). The ~~F~~fracture toughness of ~~the~~ ferritic materials selected for the ESF systems meets ~~the~~ Code requirements ~~of the Code~~.

   The controls on the use and fabrication of ~~the~~ austenitic stainless steel ~~of the~~ in ESF systems satisfy the ~~requirements~~positions 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 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 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, constitute an acceptable basis for meeting the requirements of ~~General Design Criteria~~ GDC 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 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 ~~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 requirementspositions of Regulatory Guide 1.36 form a is the basis for meeting the requirements of GDC 1, 14, and 31.

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."

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.

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, Appendix B.

For design certification reviews and combined license 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 the ITAAC, including design acceptance criteria (DAC), and as applicable, including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP Section. [Highlighted text reflects additional language added to the latest revision of this paragraph. Strike out text above is to be removed from the document after OGC review - It was provided to show the previous language in reference to 10 CFR Part 52.]

V. IMPLEMENTATION

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

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

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, unless superceded 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 ~~which~~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 Part 50, Appendix A, "General Design Criteria," and Appendix B, "Quality Assurance Requirements for Nuclear Power Plants and Fuel Reprocessing Plants."~~

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

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."

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."

~~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."~~

15. Regulatory Guide 1.84~~5~~, "Design, Fabrication and Materials Code Case Acceptability ASME Section III ~~Division 1~~."

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 No. 88-01)," January 25, 1988.

~~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).~~

~~18~~18. Branch Technical Position ~~EMCB~~ ~~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.

20~~3~~. ASTM A-262-1970, "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."

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

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the draft Standard Review Plan are covered by the requirements of 10 CFR Part 50.54, which were approved by the Office of Management and Budget, approval number 3150 - 0011.

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.

BRANCH TECHNICAL POSITION EMCB MTEB 6-1
(Currently the responsibility of the Materials and Chemical Engineering Branch (EMCB)MTEB)organization responsible for review of component integrity issues related to engineered safety features)

pH FOR EMERGENCY COOLANT WATER FOR PWRsPRESSURIZED WATER REACTORS

A. Background

To establish the minimum value of pH in post-accident containment sprays in pressurized water reactors (PWRs), the Chemical Engineering Branch NRC staff has reviewed the available information and recommended the criteria listed in the Bbranch Ttechnical Pposition below.

The minimum pH value of 7.0 follows from the Westinghouse report (Ref.erence 1) 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

CMEBThe 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 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.

**All pH values are at 25EC.

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).

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.

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SRP Draft Section 6.1.1
Description of Changes

(NOTE: Description of Changes follows the organization of SRP Section 6.1.1. In all instances strikeout on top of redline designates language that was introduced into previous draft revisions of the SRP section and was subsequently eliminated for this revision of the SRP section.)

General editorial and formatting changes to eliminate ambiguity and generally enhance to the readability of the SRP.

For currently defined acronyms, replaced defined term with the acronym for occurrences following the acronym definition (e.g., GDC, ESF, RCPB, LOCA, DBA, BWR, PWR).

In five occurrences, replaced "which" with "that" to reflect proper grammar. (pp. 5 (2 occurrences), 8, 10 and 13)

REVIEW RESPONSIBILITIES - ~~Reflects changes in review branches~~ Replaced specific branches with functional responsibilities to preclude need for SRP revisions resulting from reorganization and branch consolidation. (p. 1) Change is reflected throughout the SRP.

I. AREAS OF REVIEW:

Editorial change to reference 10 CFR 50.55a. (p. 1) Change is reflected throughout the SRP.

Deleted a statement pertaining to the review of corrosion rates related to hydrogen generation as this statement represents a review interface addressed later in this SRP. (pp. 2)

Re-organized areas of review by deleting differentiation between "primary review areas" and "secondary review areas." To the extent practicable, the five areas of review will be followed throughout the Areas of Review, Acceptance Criteria (specific criteria), and Review Procedures subsections of this SRP: (1) Materials and Fabrication; (2) Composition and Compatibility of ESF Fluids; (3) Component and Systems Cleaning; (4) Thermal Insulation; and (5) ITAAC. (pp. 2 - 3)

Relocated the sentence pertaining to the review of controls of contaminants and the evaluation of the effects on nonmetallic insulation associated with exposure to contaminants to the review area for Thermal Insulation. (pp. 2 - 3)

Revised areas of review to eliminate references to branch responsible for performance of the reviews. (pp. 2 - 3)

C. Inspection, Test, Analysis, and Acceptance Criteria (ITAAC)

This subsection was added for the purpose of addressing design certification and combined license reviews performed pursuant to 10 CFR Part 52. (p. 3)

Review Interfaces subsection was added. Subsection captures related reviews under other SRP sections ~~and lists interfaces with other branches~~. (p. 3)

Editorial change to add SRP titles after first mention of each SRP number. (p. 3)

II. ACCEPTANCE CRITERIA

Citations of 10 CFR Regulations are now listed alphabetically. A citation of 10 CFR 52.97(b)(1) was added in reference to ITAAC requirements for design certification and combined license reviews. (p. 4)

Revised summary of 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 14 to add the word "of" before each of the potential failure mechanisms (abnormal leakage, rapidly propagating failure, and gross failure) to accurately repeat the requirements in the Commission regulations; thereby reflecting that the probability of failure from each mechanism may be independent of the others. This change is repeated throughout this SRP. (p. 4)

Revised summary of 10 CFR Part 50, Appendix A, GDC 31 and 35 to more accurately reflect the requirements in the Commission regulations. (p. 4)

Revised summary of 10 CFR Part 50, Appendix B, Criteria IX and XIII to more accurately reflect the requirements in the Commission regulations. (p. 4)

Re-organized specific criteria so that the organization of this section correlates with re-organized Areas of Review subsection. (pp. 4 - 7)

Under the specific review criteria, eliminated the distinction between "criteria for primary review areas" and "criteria for secondary review areas," as only primary review areas are addressed in this subsection.

1. Materials and Fabrication

a. Austenitic Stainless Steels

Subparagraph (1) deleted because the offset yield strength value is unsubstantiated. Renumbering of items resulted from this deletion. (p. 5)

Original subparagraph (3) deleted (pp. 5-6) and replaced by new subparagraph (4). (p. 5)

Subparagraph (3) added because of specific criteria for abrasive work on stainless steel surfaces based upon the Regulatory Guide 1.37 position related to abrasive work operations. (p. 5)

Subparagraph (4) replaces deleted subparagraph (3) for addressing the criteria in Attachment A to GL 88-01 and NUREG-0313 that are needed to assure adequate resistance to IGSCC for susceptible BWR ESF piping. (p. 5)

b. Ferritic Steel Welding

Subparagraph on acceptable alternate procedures for ferritic steel welding was added for the 1996 draft revision of this SRP section to explicitly identify an acceptable alternative control to Regulatory Guide 1.50 as stated in the 1996 draft revision of SRP Section 5.2.3. This subparagraph is deleted for the current revision of this SRP section and in SRP Section 5.2.3 because the references for this alternative are from the 1970s and do not reflect current knowledge and technology. (p. 6)

2. Composition and Compatibility of Engineered Safety Feature Fluids

b. Boiling Water Reactors (BWRs)

Limits on the conductivity, chloride concentration, and pH are updated consistent with current industry guidelines. (p. 6)

Technical Rationale subsection introduced as part of the SRP updated format. (pp. 7 - 9) Revised technical rationale designations to correlate with designations used in Acceptance Criteria subsection (i.e., used capital letters rather than numbers.)

In the paragraph discussing Criterion XIII under subparagraph (G), deleted two sentences pertaining to ESF functions, as they are a word-for-word repeat of two sentences in the previous paragraph for Criterion IX. (p. 9)

III. REVIEW PROCEDURES

Revised introductory section to conform with updated SRP guidance in LIC-200. (p. 9)

Reorganized and renumbered review procedures so that the organization of this section correlates with re-organized Areas of Review subsection. (pp. 9 - 11)

~~A~~1. Materials and Fabrication

~~1~~a. Material Specification

Added a reference to regulatory guide 1.84 regarding acceptable material Code Cases, as well as a reference to GL 88-01and NUREG-0313 concerning for ESF piping in BWRs. (p. 9)

~~2~~b. Nickel-Chromium-Iron Alloys

Added review procedures for nickel-chromium-iron alloys proposed as ESF materials, based on more recent operating experience. (p. 9)

~~3~~c. Austenitic Stainless Steels

Added review procedures ~~for~~ applicable to BWR austenitic stainless steel ESF piping exposed to reactor coolant during power operation and a method identified as a previously accepted alternative to the weld qualification/non-sensitization verification guidance of Regulatory Guide 1.44 in SRP Section 5.2.3. (pp. 9 - 10)

Subparagraph (~~4~~d) added to address review procedures of corrosion allowances for ESF materials. (p. 10)

Subparagraph (~~5~~e) added to address review of abrasive work controls for stainless steel surfaces. (p. 10)

Deleted the subsection heading, "Process Fluids and Compatibility," as to conform with organization throughout this SRP section. (p. 10)

Relocated the paragraphs third and fourth paragraphs to new subsections (3) and (4) for "Component and Systems Cleaning," and "Thermal Insulation," to conform with organization throughout this SRP section. (pp. 10 - 11)

12. Composition and Compatibility of ESF Fluids

a. Pressurized Water Reactors (PWRs)

Augmented paragraph to further elaborate on the review criteria addressed and subject to review in conformance with in Regulatory Guide 1.7, which is now subject to review by EMCB. (p. 10)

~~2. Compatibility With Other Process Fluids~~

~~This paragraph was added to address the review of the compatibility of ESF materials with process fluids other than ESF system fluids. (pp. 12-13)~~

Deleted "Compatibility With Other Process Fluids" subsection, as it pertains to the review interface for the acceptability of the reactor coolant chemistry and associated chemistry controls performed under SRP Sections 5.4.8 and 9.3.4 (Review Interface 4. in Section I of this SRP.) (p. 11)

End of subsection III: Paragraph introduced based on its applicability to standard design certification reviews and combined license reviews under 10 CFR Part 52. The strike out text immediately preceding the paragraph designates strike out text to be removed following OGC review. (p. 11)

IV. EVALUATION FINDINGS

Added findings for BWR austenitic stainless steel piping related to conformance with Generic Letter 88-01 positions and NUREG-0313, Revision 2 recommendations. (p. 12)

The last paragraph addresses the performance of design certification reviews and combined license reviews pursuant to 10 CFR Part 52. (p. 12)

V. IMPLEMENTATION

Added boiler-plate text to implementation subsection in reference to 10 CFR Part 52. (p. 13)

Added third paragraph based on applicability of the section to new applications. (p. 13)

Added text 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). (pp. 13 - 14)

VI. REFERENCES

References updated to reflect applicable regulations, guidance, and renumbered per updated SRP format. (p. 14)

Added PAPERWORK REDUCTION ACT STATEMENT and Public Protection Notification per updated SRP format. (p. 14)

BRANCH TECHNICAL PAPER - Extracted BTP from SRP to create separate document. Added footnotes, Paperwork Reduction Act Statement, and Public Protection Notification as required for stand-alone documents. Renumbered BTP to eliminate reference to primary review branch. Reformatted subsection headers to agree with SRP format.