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(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

5.2.3 REACTOR COOLANT PRESSURE BOUNDARY MATERIALS

REVIEW RESPONSIBILITIES

Primary - Materials Engineering Branch (MTEB)

Secondary - Chemical Engineering Branch (CMEB)

I. AREAS OF REVIEW

The following areas, which relate to materials of the reactor coolant pressure boundary (RCPB) other than the reactor pressure vessel, which is covered in Standard Review Plan Section 5.3.1, "Reactor Vessel Materials," are reviewed by MTEB and CMEB as indicated.

1. Material Specifications

   The specifications for pressure-retaining ferritic materials, nonferrous metals and austenitic stainless steels, including weld materials, that are used for each component (e.g., vessels, piping, pumps, and valves) of the reactor coolant pressure boundary, are reviewed by MTEB.

   The adequacy and suitability of the ferritic materials, stainless steels, and nonferrous metals specified for the above applications are determined.

2. Compatibility of Materials with the Reactor Coolant

   General corrosion and stress corrosion cracking induced by impurities in the reactor coolant can cause failures of the reactor coolant pressure boundary.

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

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

Similarly, a review by MTEB is made of possible uses of austenitic stainless steels in the sensitized condition. The use of austenitic stainless steels in any condition in boiling water reactors (BWR's) requires special attention because of the oxygen content of BWR coolant.

3. Fabrication and Processing of Ferritic Materials

Items 3.a, 3.b, and 3.c are reviewed by MTEB.

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

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

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

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

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

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

   (2) The quality of electroslag welds in low alloy steel components can be increased by maintaining a weld solidification pattern that possesses a strong intergranular bond in the center of the weld. The welding variables, which have a significant effect on the weld solidification pattern, must be controlled. The welding variables, solidification patterns, macro etch tests, and Charpy V-notch impact tests of electroslag welds are reviewed.

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

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

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

4. Fabrication and Processing of Austenitic Stainless Steel

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

Items 4.a, 4.b, 4.d, and 4.e are reviewed by MTEB; and item 4.c is reviewed by CMEB. Upon request the CMEB will review corrosion testing data.

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

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

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

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

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

d. Austenitic stainless steel is subject to hot cracking (microfissuring) during welding if the weld metal composition or the welding procedure is not properly controlled. Because cracks formed in this manner are small and difficult to detect by nondestructive testing methods, welding procedures, weld metal compositions, and delta ferrite percentages that minimize the possibility of hot cracking must be specified. As a part of achieving this control, Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal," contains recommendations for process control through the testing of weld test pads. The staff recommendations will provide assurance that the ferrite content will be adequate to prevent microfissuring. The adequacy of the proposed welding procedures is reviewed.

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

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

Experience has shown that a welder qualified to weld stainless steel components under normal fabricating conditions may not produce acceptable welds if the accessibility to the weld area is restricted.

Limited accessibility can occur when component parts are joined in the final assembly or at the plant site, where other adjacent components or structures prevent the welder from assuming an advantageous position during the welding operation. The adequacy of accessibility of field erected structures, for welding austenitic stainless steel components, is reviewed.

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

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

Inservice inspection requirements for the RCPB are described in SRP Section 5.2.4, "Inservice Inspection and Testing of Reactor Coolant Pressure Boundary."

The review for Quality Assurance is coordinated and performed by the Quality Assurance Branch as part of its primary review responsibility for Standard Review Plan Sections 17.1 and 17.2. The acceptance criteria necessary for the review and methods of application are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in subsection I of this SRP section describe methods to meet the requirements of the Commission's regulations in 10 CFR Part 50 given below:

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

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

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

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

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

6. Section 50.55a, as it relates to quality standards and fracture toughness.

Specific acceptance criteria necessary to meet the relevant requirements of Commission regulations identified above are:

1. Material Specifications

   The requirements of GDC 1, GDC 30, and §50.55a regarding quality standards are met for material specifications by compliance with the applicable provisions of the ASME Code and by compliance with the recommendations of Regulatory Guide 1.85.

The specifications for permitted materials are those identified in the ASME Code, Section III, Appendix I, or described in detail in the ASME Code, Section II, Parts A, B, and C. Regulatory Guide 1.85, "Code Case Acceptability ASME Section III Materials," describes the acceptable Code Cases to be used in conjunction with the above specifications. (Applicable to materials reviewed in item I.1 by MTEB.)

Special requirements for BWR piping materials and materials processing are described in NUREG-0313, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping."

2. <u>Compatibility of Materials with the Reactor Coolant</u>

The requirement of GDC 4 relative to compatibility of components with environmental conditions are met by compliance with the applicable provisions of the ASME Code and by compliance with the recommendations of Regulatory Guide 1.44.

Ferritic low alloy steels and carbon steels, which are used in many principal pressure-retaining components, are clad with a layer of austenitic stainless steel. If cladding is not used, conservative corrosion allowances must be indicated for all exposed surfaces of carbon and low alloy steels, as indicated in the ASME Code, Section III, NB-3120, "Corrosion." (Applicable to materials reviewed by CMEB as specified in item I.2.)

Unstablilized austenitic stainless steel of the AISI Type 3XX series used for components of the RCPB must conform to the recommendations of Regulatory Guide No. 1.44, "Control of the Use of Sensitized Stainless Steel," and the positions of NUREG-0313, including verification of nonsensitization of the material by an approved test. (Applicable to materials reviewed by MTEB as specified in item I.1.)

3. <u>Fabrication and Processing of Ferritic Materials</u>
(Applicable to materials reviewed by MTEB as specified in items I.3.a, I.3.b, and I.3.c.)

a. The acceptance criteria for fracture toughness are the requirements of Appendix G, "Fracture Toughness Requirements," of 10 CFR Part 50. These criteria satisfy the requirements of GDC 14, GDC 31, and §50.55a regarding prevention of fracture of the RCPB.

Appendix G requires that the pressure-retaining components of the RCPB that are made of ferritic materials shall meet the requirements for fracture toughness during system hydrostatic tests and any condition of normal operation, including anticipated operational occurrences. With respect to absorbed energy in ft-lbs and lateral expansion as shown by Charpy V-notch (C_v) impact tests, all materials shall meet the acceptance standards of Article NB-2300 of the Code, Section III, and the requirements of Sections IV.A.2 and IV.A.3 of Appendix G, 10 CFR Part 50, as follows:

(1) The special acceptance requirements for fracture toughness of reactor vessels are covered by Standard Review Plan Section 5.3.1, "Reactor Vessel Materials."

(2) Materials for piping (i.e., pipes, tubes, and fittings), pumps, and valves, excluding bolting materials, shall meet the requirements of the Code, Section III, Paragraph NB-2332, and Appendix G, Paragraph G-3100. The required C_v values for piping are specified in Table NB-2332-1 of the Code, Section III.

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

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

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

(1) The amount of specified preheat must be in accordance with the requirements of the Code, Section III, Appendix D, Paragraph D-1200, supplemented by Regulatory Guide 1.50, "Control of Preheat Temperature for Welding Low Alloy Steel."

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

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

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

The preheat controls described in the Westinghouse Topical Report WCAP-8577 are an acceptable alternate to compliance with those of Regulatory Guide 1.50.

(2) The acceptance criteria for electroslag welds are presented in Regulatory Guide 1.34, "Control of Electroslag Weld Properties." These criteria specify acceptable solidification patterns and impact test limits (for qualification of welds in Class 1 and Class 2 components) and the criteria for verifying conformance during production welding.

(3) Regulatory Guide 1.71, "Welder Qualification for Areas of Limited Accessibility," provides the following criteria for requalification of welders: the performance qualification should require testing of the welder when conditions of

accessibility to a production weld are less than 30 to 35 cm (12-14 inches) in any direction from the joint; and requalification is required for different restricted accessibility conditions or when any of the essential variables listed in the Code, Section IX, are changed.

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

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

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

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

a. The requirement of GDC 4 relative to compatibility of components with environmental conditions are met regarding measures to avoid sensitization in austenitic stainless steels. The acceptance criteria for testing, alloy compositions, and heat treatment, to avoid sensitization in austenitic stainless steels, are covered in Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel," and additional criteria for BWRs are in NUREG-0313. (Applicable to materials reviewed by MTEB as specified in item I.4.a.)

b. The requirements of GDC 4 relative to compatibility of components with environmental conditions are met regarding additional controls to avoid stress corrosion cracking in austenitic stainless steels. These controls consist of acceptance criteria on prevention of contamination, cleaning, and upper limit on yield strength.

Controls to avoid stress corrosion cracking in austenitic stainless steels are also covered in Regulatory Guide 1.44. This guide provides acceptance criteria on the cleaning and protection of the material against contaminants capable of causing stress corrosion cracking. Acid pickling is to be avoided on fabricated stainless steels. Necessary pickling is to be done only with appropriate controls. Pickling should not be performed upon sensitized stainless steels. (Applicable to materials reviewed by MTEB as specified in item I.4.b.)

The quality of water used for final cleaning or flushing of finished surfaces during installation is in accordance with Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water Cooled Nuclear Power Plants." Vented tanks with deionized or demineralized water are an acceptable source of water for final cleaning or flushing of finished surfaces. The oxygen content of the water need not be controlled. (Applicable to water specified in Regulatory Guide 1.44 used for final cleaning or flushing of finished stainless steel surfaces, and reviewed by CMEB.)

Laboratory stress corrosion tests and service experience provide the basis for the criterion that cold-worked austenitic stainless steels used in the reactor coolant pressure boundary should have an upper limit on the yield strength of 90,000 psi. (Applicable to material reviewed by MTEB in item I.4.b.)

c. The acceptance criteria for compatibility of austenitic stainless steel with thermal insulation are based on Regulatory Guide 1.36 to satisfy GDC 14 and 31 relative to prevention of failure of the RCPB. The compatibility of austenitic stainless steel materials with thermal insulation is dependent upon the type of insulation. The thermal insulation is acceptable if either reflective metal insulation is employed or a nonmetallic insulation which meets the criteria of Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel," is used. The acceptance criteria for nonmetallic insulation for stainless steel are based on the levels of leachable contaminants in the material and are presented in position C.2.b and Figure 1 of the guide. (Applicable to material reviewed by CMEB in item I.4.c.)

d. The acceptance criteria for control of welding of austenitic stainless steels are based on Regulatory Guides 1.31, 1.34, and 1.71 to satisfy the quality standards requirements of GDC 1, GDC 30, and §50.55a. (Item II.4.d is applicable to material reviewed by MTEB as specified in item I.4.d.)

The acceptance criteria for delta ferrite in austenitic stainless steel welds are given in Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal." These acceptance criteria cover (1) verification of delta ferrite content of filler metals, (2) ferrite measurement, (3) instrumentation, (4) acceptability of test results, and (5) documentation of weld pad verification test.

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

Regulatory Guide 1.71, "Welder Qualification for Areas of Limited Accessibility," provides the following criteria for requalification of welders:

(1) The performance qualification should require testing of the welder when conditions of accessibility to a production weld

are less than 30 to 35 cm (12-14 inches) in any direction from the joint.

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

e. For nondestructive examination of austenitic stainless steel tubular products, the quality standards requirements of GDC 1, GDC 30, and §50.55a are met by compliance with the applicable provisions of the ASME Code. The acceptance criteria are given in Section III of the Code, Paragraph NB-2550. (Item II.4.e. is applicable to material reviewed by MTEB as specified in item I.4.e.)

III. REVIEW PROCEDURES

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

For each area of review described in subsection I of this SRP section,the following review procedures are followed:

1. Material Specifications

The material specifications for each major pressure-retaining component or part used in the RCPB are compared with the acceptable specifications listed in the Code, Sections II and III, as stated in the acceptance criteria. Exceptions to the material specifications of the Code are clearly identified, and the basis evaluated. The reviewer judges the significance of the exceptions and, taking into account precedents set in earlier cases, determines the acceptability of the proposed exceptions. In those instances where the Materials Engineering Branch takes exception to the use of a specific material or questions certain aspects of a specification, the applicant is advised which material is not acceptable, and for what reason.

2. Compatibility of Materials with the Reactor Coolant

The reviewer verifies that the following information is provided at each respective stage of the review process:

a. At the construction permit stage of review:

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

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

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

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

(1) The items listed under subsection III.2.a above, to provide assurance that any changes are noted that may have occurred during the period between the submittal of SARs.

3. Fabrication and Processing of Ferritic Materials

a. The information submitted by the applicant relative to tests for fracture toughness is reviewed for conformance with the acceptance criteria stated in subsection II.3.a. These tests include Charpy V-notch impact and dropweight tests. A description of the tests is reviewed, and the locations of the test specimens and their orientation are verified. Information regarding calibration of instruments and equipment is reviewed for conformance with the acceptance criteria stated in subsection II.3.a.(4) of this SRP section.

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

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

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

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

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

(3) The ASME Code, Section III, requires adherence to the requirements of Section IX, "Welding Qualifications." One of the requirements is welder qualification for production welds. However, there is a need for supplementing this section of the Code because the assurance of providing satisfactory welds in locations of restricted direct physical and visual accessibility can be increased significantly by qualifying the welder under conditions simulating the space limitations under which the actual welds will be made.

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

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

c. The ASME Code, Section III, NB-2550 specifies the ultrasonic method for examination of ferritic steel tubular products.

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

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

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

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

(3) Controls to verify non-sensitization, as described in Regulatory Guide 1.44.

(4) For BWRs, additional processing controls, as described in NUREG-0313.

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

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

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

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

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

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

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

d. The information submitted by the applicant regarding control of delta ferrite in austenitic stainless steel welds is reviewed to determine its conformance with the acceptance criteria stated in subsection II.4.d of this SRP section. The information submitted must state that appropriate filler metal acceptance tests have been conducted and that a certified materials test report has been received. The information should state, also, the applicant's program for compliance with the staff positions in Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal."

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

   The review of information on the control of electroslag weld properties in austenitic stainless steels is essentially the same as that discussed previously for ferritic steels. However, because electroslag-welded austenitic stainless steels have very high impact resistance and because the Code, Section III, is not concerned with impact testing of these welds, the checks are: (1) a macroetch test is used to provide assurance that the solidification pattern is in accordance with the requirement of the acceptance criteria shown in subsection II.4.d of this SRP section, and (2) wrought stainless steel parts are solution heat treated after welding.

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

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

5. General

If the information contained in the safety analysis reports or the plant Technical Specifications does not comply with the appropriate acceptance criteria, or if the information provided is inadequate to establish such compliance, a request for additional information is prepared and transmitted. Such requests identify not only the necessary additional information but also the changes needed in the SAR or the Technical Specifications. Subsequent amendments received in response to these requests are reviewed for compliance with the applicable acceptance criteria.

IV. EVALUATION FINDINGS

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

The staff concludes that the plant design is acceptable and meets the requirements of General Design Criteria 1, 4, 14, 30, and 31 of Appendix A of 10 CFR Part 50; the requirements of Appendices B and G of 10 CFR Part 50; and the requirements of §50.55a of 10 CFR Part 50. This conclusion is based on the staff's review of the SAR.

The materials used for construction of components of the reactor coolant pressure boundary (RCPB) have been identified by specification and found to be in conformance with the requirements of Section III of the ASME Code and [for BWRs only] in conformance with the requirements of NUREG-0313. Compliance with the above Code provisions for material specifications satisfies the quality standards requirements of GDC 1, GDC 30, and §50.55a.

The materials of construction of the RCPB exposed to the reactor coolant have been identified and all of the materials are compatible with the primary coolant water, which is chemically controlled in accordance with appropriate technical specifications. This compatibility has been proven by extensive testing and satisfactory performance. This includes conformance with the recommendations of Regulatory Guide 1.44, "Control of Sensitized Stainless Steel," and [for BWRs only] conformance with the requirements of NUREG-0313. General corrosion of all materials, except unclad carbon and low alloy steel, will be negligible. For these materials, conservative corrosion allowances have been provided for all exposed surfaces in accordance with the requirements of the Code, Section III. The above evidence of compatibility with the coolant and compliance with the Code provisions satisfy the requirements of GDC 4 relative to compatibility of components with environmental conditions.

The materials of construction for the RCPB are compatible with the thermal insulation used in these areas and are in conformance with the recommendations of Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steels." Conformance with the above recommendations satisfy the requirements of GDC 14 and GDC 31 relative to prevention of failure of the RCPB.

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

The fracture toughness tests required by the ASME Code, augmented by Appendix G, 10 CFR Part 50, provide reasonable assurance that adequate safety margins against nonductile behavior or rapidly propagating fracture can be established for all pressure retaining components of the reactor coolant pressure boundary. The use of Appendix G of the ASME Code, Section III, and the results of fracture toughness tests performed in accordance with the Code and NRC regulations in establishing safe operating procedures, provides adequate safety margins during operating, testing, maintenance, and postulated accident conditions. Compliance with these Code provisions and NRC regulations satisfies the requirements of GDC 31 and §50.55a regarding prevention of fracture of the reactor coolant pressure boundary.

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

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

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

The controls to avoid stress corrosion cracking in reactor coolant pressure boundary components constructed of austenitic stainless steels limit yield strength of cold-worked austenitic stainless steels to 90,000 psi maximum and conform to the recommendations of Regulatory Guides 1.44, "Control of the Use of Sensitized Stainless Steel," and 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water Cooled Nuclear Plants." The controls followed in accordance with these recommendations, during material selection, fabrication, examination, and protection, in order to prevent excessive yield strength, sensitization, and contamination, provide reasonable assurance that the RCPB components of austenitic stainless steels will be in a metallurgical condition that minimizes susceptibility to stress corrosion cracking during service. These controls meet the requirements of GDC 4 relative to compatibility of components with environmental conditions and the requirements of GDC 14 relative to prevention of leakage and failure of the RCPB.

The controls imposed during welding of austenitic stainless steels in the RCPB are in accordance with the recommendations of Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal," Regulatory Guide 1.34, and Regulatory Guide 1.71. These controls provide reasonable assurance that welded components of austenitic stainless steel will not develop microfissures during welding and will have high structural integrity. These controls meet the quality standards requirements of GDC 1, GDC 30, and §50.55a and satisfy the requirements of GDC 14 relative to prevention of leakage and failure of the RCPB.

V. IMPLEMENTATION

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

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

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

VI. REFERENCES

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

2. 10 CFR Part 50, Appendix G, "Fracture Toughness Requirements."

3. 10 CFR Part 50, Section 50.55a.

4. ASME Boiler and Pressure Vessel Code, Section II, Parts A, B, and C, Section III, and Section IX, American Society of Mechanical Engineers.

5. ASTM, A-262, Practice E, "Copper-Copper Sulfate-Sulfuric Acid Test for Detecting Susceptibility to Intergranular Attack in Stainless Steels," Annual Book of ASTM Standards, American Society for Testing and Materials.

6. ASTM E 23, "Notched Bar Impact Testing of Metallic Materials," Annual Book of ASTM Standards, American Society for Testing and Materials.

7. ASTM E-208, "Standard Method for Conducting Dropweight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels," Annual Book of ASTM Standards, American Society for Testing and Materials.

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

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

10. Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel."

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

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

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

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

15. Regulatory Guide 1.71, "Welder Qualification for Areas of Limited Accessibility."

16. Regulatory Guide 1.85, "Code Case Acceptability ASME Section III Materials."

17. NUREG-0313, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping." (This document replaces Branch Technical Position MTEB 5-7, "Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping.")

18. WCAP-8577, "The Application of Preheat Temperatures After Welding Pressure Vessel Steels," Westinghouse Electric Corporation (Sept. 1975, Approved by Letter J. F. Stolz to C. Eicheldinger, June 18, 1976).

BRANCH TECHNICAL POSITION MTEB 5-7
MATERIAL SELECTION AND PROCESSING
GUIDELINES FOR BWR COOLANT PRESSURE BOUNDARY PIPING

(BTP MTEB 5-7 has been superseded by NUREG 0313).