**UNITED STATES**
**NUCLEAR REGULATORY COMMISSION**
**ADVISORY COMMITTEE ON REACTOR SAFEGUARDS**
**WASHINGTON, DC 20555 - 0001**

February 24, 2011

Mr. R. W. Borchardt
Executive Director for Operations
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: DRAFT FINAL REGULATORY GUIDES 1.34, 1.43, 1.44, AND 1.50

Dear Mr. Borchardt:

During the 580$^{th}$ meeting of the Advisory Committee on Reactor Safeguards, February 10-12, 2011, we reviewed Draft Final Revision 1 to Regulatory Guides (RGs) 1.34, 1.43, 1.44, and 1.50. Our Materials, Metallurgy, and Reactor Fuels Subcommittee also reviewed this guidance during a meeting on October 21, 2010. During these meetings we met with the NRC staff and had the benefit of the documents referenced.

**RECOMMENDATIONS**

1. Draft Final Revision 1 to Regulatory Guides 1.34, 1.43, and 1.50 should be issued.

2. Draft Final Revision 1 to Regulatory Guide 1.44 should not be issued until the following changes are made:

    a. The language proposed by the staff during our February 10-12, 2011 meeting should be incorporated into the guide to address our concerns on the use of standard grade stainless steels and the description of Pressurized Water Reactor (PWR) water chemistry.

    b. Guidance should be added to address the deleterious effects of cold work and post weld grinding on Intergranular Stress Corrosion Cracking (IGSCC) and Irradiation Assisted Stress Corrosion Cracking (IASCC) susceptibility of welded AISI Type 300 stainless steel components.

**BACKGROUND**

The subject draft guides discuss acceptable methods to satisfy requirements of 10 CFR 50 Appendix A General Design Criteria (GDC) 1 and 30 related to the design, fabrication, and testing of nuclear power plant components, and GDC 4 as it relates to compatibility of components with environmental conditions. Materials addressed include low-alloy ferritic steels used to fabricate components such as reactor pressure vessels and steam line piping, and AISI Type 300 austenitic stainless steels used to fabricate components such as primary coolant piping and core internals. These revisions are needed to bring existing regulatory guides into conformance with the American Society of Mechanical Engineers (ASME) code, improved fabrication methods, and lessons learned from operating experience. These guides will be applied to the fabrication of new reactors, as well as to the maintenance and repair of operating plants.

**DISCUSSION**

Draft Final Revision 1 to Regulatory Guide 1.34, "Control of Electroslag Weld Properties," addresses the qualification of processes used for joining both low-alloy steels and stainless steels using the electroslag process. Compliance with this guide will provide assurance that electroslag welds will not develop microfissures during welding and that the welds will have adequate toughness and safety margins during normal operation and during postulated accidents.

Draft Final Revision 1 to Regulatory Guide 1.43, "Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components," addresses processes used in the cladding of ferritic steels with corrosion resistant stainless steels. Underclad cracking can occur when initial or subsequent welding passes generate excessive temperatures in the low-alloy steel substrate. This guide discourages the use of high-heat input submerged-arc welding procedures and coarse-grained materials known to be susceptible to underclad cracking. For susceptible steels, the guide provides stringent supplementary qualification guidance and controls beyond those required by the ASME code. This supplementary guidance does not apply to the weld cladding of resistant steels. Compliance with this guide will assure that underclad cracking formed during welding or post-weld heat treatment of susceptible (i.e., coarse-grained) low-alloy steels will be detected and repaired. More importantly, this guide encourages the use of steels with microstructures that are resistant to underclad cracking.

Draft Final Revision 1 to Regulatory Guide 1.50, "Control of Preheat Temperature for Welding of Low-Alloy Steel," addresses cracking phenomena encountered during welding of low-alloy ferritic steels. During welding, excessive temperatures or cooling rates can produce undesirable phase transformations or hydrogen concentrations, and result in localized embrittlement and crack formation in weld heat affected zones. To assure high quality welds and to minimize the risk of cracking, guidance is provided for weld qualification and production. This guidance is based on extensive industry experience and an understanding of the mechanisms responsible for cracking. Specifically, controls are placed on metal temperature, preheat, cooling rate, post weld heat treatment, and hydrogen bake out procedures. Use of this guide will assure that the best industry practices are used in the welding of safety-related low-alloy steels.

Draft Final Revision 1 to Regulatory Guide 1.44, “Control of the Processing and Use of Stainless Steel,” applies to austenitic stainless steel components used in:

- the reactor coolant pressure boundary,
- systems required for reactor shutdown,
- systems required for emergency core cooling, and
- reactor vessel internals that are relied on for adequate core cooling.

Guidance is provided on materials, coolant environments, and fabrication practices to minimize the risk of stress corrosion cracking of non-stabilized AISI Type 300 austenitic stainless steels in reactor service. There are several stainless steel alloys within this category, but those most commonly used in nuclear plants are Types 304 and 316 which limit carbon concentrations to < 0.08 weight percent; low-carbon Types 304L and 316L which limit carbon concentrations to < 0.03 weight percent; and low-carbon, high-nitrogen Types 304 LN and 316 LN. The focus of this guide is on the prevention of IGSCC susceptibility of these steels caused by sensitization. Sensitization occurs in stainless steels when they are held at a sufficiently high temperature for a sufficient length of time to cause intergranular precipitation of chromium carbides. This precipitation depletes the dissolved chromium concentration in the grain boundaries, and these depleted grain boundaries become susceptible to IGSCC. Industrial welding and furnace annealing processes can sensitize stainless steel components and make them susceptible to IGSCC in both boiling water reactor (BWR) and PWR coolant environments, if the environments are sufficiently oxidizing, and if tensile stresses are sufficiently high. Weld sensitization is now routinely avoided in the nuclear industry by the use of low-carbon or low-carbon, high-nitrogen stainless steels.

Draft Final Revision 1 to Regulatory Guide 1.44 has not changed significantly from the original guide issued in the early 1970s. While much of the guidance provided is still valid, it needs to be improved.

Use of Standard Carbon Stainless Steels

The majority of IGSCC failures in BWRs have occurred in furnace sensitized, weld sensitized, or cold worked standard carbon stainless steel components. Although far less frequent, IGSCC failures in PWRs have occurred in weld sensitized and cold worked standard carbon stainless steel components. Despite this unfavorable experience, the draft guide accepts the use of welded, standard carbon stainless steels for PWR safety-related components, provided that certain limitations are met.

For BWR components subjected to furnace heat treatments, the guide provides materials testing guidance beyond that required by the ASME code. It is our view that these tests do not provide adequate assurance of IGSCC resistance. No data have been provided or referenced by the staff showing that success in the specified tests insures IGSCC resistance in reactor coolant environments. Indeed, the staff's guidance on materials for BWR piping, NUREG-0313, Revision 2, does not credit these tests as demonstrating resistance to IGSCC.

The use of low-carbon stainless steels in combination with modern water chemistry controls greatly reduces the likelihood of IGSCC and IASCC, and these practices should be emphasized in the guide. This recommendation is consistent with current industry practice. The staff has agreed to address our concerns on this subject by including a statement in the guide that low-carbon stainless steels should be used in applications in contact with reactor coolants. However, the guide still permits the use of standard stainless steels under specific conditions.

Reactor Water Coolant Chemistry

Although the guide encourages the use of low-carbon stainless steels in BWR applications in contact with reactor coolant, it accepts the use of standard carbon stainless steels in PWR primary coolants. During normal operation, PWR coolants are typically controlled to maintain dissolved oxygen levels at 0.005 ppm or less. Under unusual conditions, the oxygen levels may increase to levels as high as 0.1 ppm for short periods. For these conditions, use of welded standard carbon stainless steels is acceptable. However, even for PWR systems, use of low-carbon grades of stainless steel should be recommended and encouraged. The staff has agreed to include a more realistic description of PWR coolant environments in this guide.

Cold Work

The guide does not address the profound influence of cold work on the susceptibility of stainless steels to IGSCC. Cold work significantly increases the yield strength of the steel and often creates residual tensile stresses on surfaces exposed to coolant environments. Since stress corrosion susceptibility increases with applied or residual stress, cold work is capable of nucleating IGSCC and IASCC even on low-carbon stainless steels that are normally highly resistant. Severe post weld grinding is particularly deleterious.

The guide should be revised to include cautions on the deleterious effects of cold work. For example, the guidance should indicate that the use of cold worked austenitic stainless steel should be limited. Cold work of materials in pressure boundary applications should be controlled by limits on fabrication processes, such as bending, cold forming, and similar operations. It should indicate that grinding of material in contact with reactor coolant should be controlled by procedures.

Irradiation Assisted Stress Corrosion Cracking

The guide does not address the phenomenon of IASCC. Although the IASCC mechanism is not as well understood as IGSCC, there is ample evidence that the IASCC susceptibility of core internals is enhanced by sensitization and cold work, and that this susceptibility can be reduced by the choice of materials, and fabrication controls similar to those used to reduce the risk of IGSCC. This should be noted in future revisions.

Draft Final Revisions to Regulatory Guides 1.34, 1.43, and 1.50 should be issued. We look forward to reviewing a revised version of Draft Final Revision 1 to Regulatory Guide 1.44.

Sincerely,

***/RA/***

Said Abdel-Khalik
Chairman

References:


1. NRC Memorandum, "Draft Final Regulatory Guides 1.34, 1.43, 1.44, and 1.50," dated August 30, 2010 (ML102420390)
2. Draft Final Regulatory Guide 1.34, "Control of Electroslag Weld Properties," Revision 1, dated September 2010 (ML101670357)
3. Draft Final Regulatory Guide 1.43, "Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components," Revision 1, dated September 2010 (ML101670458)
4. Draft Final Regulatory Guide 1.44, "Control of the Processing and Use of Stainless Steel," Revision 1, dated September 2010 (ML101680225)
5. Draft Final Regulatory Guide 1.50, "Control of Preheat Temperature for Welding of Low-Alloy Steel," Revision 1, dated September 2010 (ML101870612)
6. American Society of Testing and Materials International A 262, "Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels," 2002
7. NUREG-0313, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," Revision 2, dated June 1986

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5. Draft Final Regulatory Guide 1.50, “Control of Preheat Temperature for Welding of Low-Alloy Steel,” Revision 1, dated September 2010 (ML101870612)
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