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

December 17, 2010

MEMORANDUM TO: ACRS MEMBERS

FROM: Michael L. Benson, Staff Engineer ***/RA/***
Reactor Safety Branch A
Advisory Committee on Reactor Safeguards

SUBJECT: CERTIFICATION OF THE MINUTES OF THE ACRS MATERIALS, METALLURGY, AND REACTOR FUELS SUBCOMMITTEE MEETING, OCTOBER 21, 2010, ROCKVILLE, MARYLAND

The minutes of the subject meeting, have been certified as the official record of the proceedings for that meeting. A copy of the certified minutes is attached.

Attachment: As stated

cc via e-mail: E. Hackett
C. Santos
A. Dias

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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WASHINGTON, DC 20555 - 0001

MEMORANDUM TO: Michael Benson, Staff Engineer
Reactor Safety Branch A, ACRS

FROM: J. Sam Armijo, Chairman
Materials, Metallurgy & Reactor Fuels Subcommittee
Reactor Safety Branch A, ACRS

SUBJECT: CERTIFICATION OF THE MINUTES OF THE MEETING OF THE SUBCOMMITTEE ON MATERIALS, METALLURGY & REACTOR FUELS ON OCTOBER 21, 2010

I hereby certify, to the best of my knowledge and belief, that the Minutes of the subject meeting held on October 21, 2010 are an accurate record of the proceedings for that meeting.

/RA/ ***December 16, 2010***

J. Sam Armijo, Chairman
Materials, Metallurgy & Reactor
Fuels Subcommittee

Date

Certified on: December 16, 2010
Certified by: J. Sam Armijo

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
Materials, Metallurgy, and Reactor Fuels Subcommittee Meeting Minutes
October 21, 2010
Rockville, MD

INTRODUCTION

The Advisory Committee on Reactor Safeguards (ACRS) Subcommittee on Materials, Metallurgy, and Reactor Fuels met on October 21, 2010, at 11545 Rockville Pike, Rockville, MD, in Room T2-B3. The purpose of the meeting was to review and discuss four draft final regulatory guides (RGs): RG 1.34, "Control of Electroslag Weld Properties;" RG 1.43, "Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components;" RG 1.44, "Control of the Processing and Use of Stainless Steel;" and RG 1.50; "Control of the Preheat Temperature for Welding of Low-Alloy Steel." The Subcommittee gathered information, analyzed relevant information and facts, and formulated proposed positions, as appropriate, for deliberation by the full ACRS. The entire meeting was open to the public. Mr. Michael Benson was the Designated Federal Official for this meeting. The Subcommittee received no written comments or requests for time to make oral statements from any members of the public regarding this meeting. The meeting was convened at 8:30 am and adjourned at 10:49 am.

ATTENDEES

ACRS

J. Sam Armijo, Chairman
Dennis Bley
Michael T. Ryan
John D. Sieber
Said Abdel-Khalik
Joy Rempe
William J. Shack via telephone

Michael Benson, ACRS Staff Engineer, Designated Federal Official

NRC Staff

Gary Stevens, Office of Research (RES)
Eric Reichelt, NRO
David Terao, NRO
Steven Downey, RES
Robert Davis, Office of New Reactors (NRO)
John Honcharik, NRO
Mekonon Bayssie, RES
Aladar Csontos, RES
Bob Hardies, Office of Nuclear Reactor Regulation (NRR)

SUMMARY OF MEETING

Opening Remarks

Chairman Armijo called the meeting to order and introduced the attending Members. The RGs being reviewed are in need of updating. Problems addressed in these documents have affected plants in the past and have even lead to regulatory shutdowns of the entire boiling water reactor (BWR) fleet.

Member Sieber requested that the staff point out where in the plants the welding applications are applied.

[pp. 5-8 in the transcript]

Overview

Mr. Stevens began by referring to backup slides that contain basic metallurgical definitions and related information.

General Information

These RGs address welding processes and weld related defects in carbon steels and stainless steels. They provide up-to-date guidance on welding processes and materials for repair activities in existing plants and for new construction. The purpose of the RGs is to provide acceptable methods to satisfy Title 10, Code of Federal Regulations, Part 50 (10 CFR 50), Appendix A, Design Criteria -1 and -30. Also, they provide an acceptable method to satisfy 10 CFR 50.55a. Controls discussed in the guides go beyond what is specified in the American Society of Engineers Boiler and Pressure Vessel Code (ASME Code), Sections III and IX. These guides are referenced in the Standard Review Plan (NUREG-0800), Section 5.2.3. RGs do not impose requirements. Applicants can choose other methods, if they can demonstrate that those methods comply with the regulations.

[pp. 8-14 in transcript, slides 3-5 in presentation]

RG 1.34: Control of Electroslag Weld Properties

Mr. Stevens said that RG 1.34 discussed electroslag welding procedures, potential defects and properties of electroslag welded ferritic or austenitic materials. Acceptable solidification patterns and impact test limits were described. Welds that do not develop microfissures will have high integrity and acceptable toughness.

[pp. 14-20 in transcript, slide 6 in presentation]

RG 1.43: Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components

RG 1.43 provides guidance to limit underclad cracking during weld-cladding. Controls on welding heat input and weld qualification procedures are used to assure that underclad cracking is minimal.

[pp. 21-24 in transcript, slide 7 in presentation]

RG 1.44: Control Processing and Use of Stainless Steel

Mr. Stevens stated that RG 1.44 contains guidance to avoid sensitization of stainless steel. The document includes guidance on testing, alloy compositions, cleaning, and heat treatment.

[pp. 24-30 in transcript, slides 8-9 in presentation]

RG 1.50: Control of Preheat Temperature for Welding of Low Alloy Steel

RG 1.50 addresses preheat temperature to prevent cold cracking after welding. Minimum preheat and maximum interpass temperatures should be specified in welding procedures, and tests should verify that cold cracking is not occurring.
[pp. 30-32 in transcript, slide 10 in presentation]

Need for Changes

The RGs are being revised because they over 30 years old and are out of date. Some practices that were exceptions to the old RGs but have since been accepted by the NRC are now included in the documents. Outdated standards referenced by the old RGs are now updated. The updates will be useful for new reactor applications and for repair/replacement activities at existing sites. Welding and materials technology changes were updated in the new version of the RGs.

[pp. 32-36 in transcript, slide 11 in presentation]

Revision Timeline

Mr. Stevens articulated that the documents were revised in the first half of 2009 and issued for public comment in the Federal Register on July 6th, 2009. After the NRC staff granted an extension, the comment period ended on October 1, 2009. Sixty-eight comments were received from Westinghouse, Dominion, EPRI, a Mr. Hung, and Babcock & Wilcox. Comments were in fact accepted through December 2009, well beyond requirements. The Nuclear Fabrication Consortium requested that the RG revisions be delayed for six months to two years, but that request was declined by NRC management. After addressing public comments, the guides were placed in internal concurrence reviews in mid July. The RGs could be published final at the end of January 2011.

[pp. 36-40 in transcript, slide 12 in presentation]

Technical Revision Summary

RG 1.34: Control of Electroslag Properties

The original guide stated that core support structures had to meet ASME Code Class 1 requirements. Currently, Subsection NG in Section III of the ASME Code deals with core supports, so the Class 1 requirement may be removed from the RG. Requirements on impact testing, which were in the original version of the guide, are now included in Subsection NC of ASME Code Section III. Regulatory Position 5 was expanded to address the welder's ability to weld in accordance with other Positions in the RG. References to outdated ASME Code articles were removed or updated.

[pp. 40-42 in transcript, slides 13 in presentation]

RG1.43: Control of Stainless Steel Weld Cladding of Low Alloy Steel

Mr. Stevens said that this RG was revised to be consistent with updated ASME Code material specifications. The discussion on underclad cracking was updated to reflect current mechanistic understanding of the cracking phenomenon. The guide now contains guidance on nondestructive examination after postweld heat treatment, and an additional test method for detection of underclad cracking has been added to the document.

[pp. 42-45 in transcript, slides 14-15 in presentation]

RG 1.44: Control of Processing and Use of Stainless Steel

The Section B Discussion was modified to require consideration of operating experience. Regulatory Position 6 now contains instructions for limiting heat input and interpass temperature during welding.

[p. 45-59 in transcript, slide 16 in presentation]

RG 1.50: Control of Preheat Temperature for Welding of Low Alloy Steel

Mr. Stevens said that discussion was added to describe the purpose of preheating. The specification of maximum interpass temperature, in accordance with ASME Code Section IX requirements, was included. ASME P material designations were added in Section C. Regulatory Position 1 was modified to require a maximum interpass temperature and minimum preheat temperature. Regulatory Position 2 now allows for postweld hydrogen bakeout, a process that has been accepted practice for a number of years. Acceptable examination procedures were clarified, and references to various outdated ASME Code articles were appropriately revised.

[pp. 59-62 in transcript, slides 17-18 in presentation]

Public Comments

Mr. Stevens stated that the NRC staff addressed all public comments and that the NRC responses would be published. All comments were aimed at improving and clarifying the requirements for the welding processes. No comments suggested completely new directions for the guidance. Mr. Stevens then gave a discussion of selected public comments, and no contentious issues were unveiled. Following this discussion, Mr. Stevens stated that the comments were received, compiled, and dispositioned. Minor comments came from review by the Office of the General Counsel.

[pp. 62-92 in transcript, slides 19-41 in presentation]

Summary and Conclusion

Mr. Stevens wrapped up his presentation by saying the NRC staff feels that the RGs are ready for publication. Chairman Armijo thanked the staff for a good presentation and adjourned the meeting.

[pp. 92-99 in transcript, slide 42 in presentation]

COMMITTEE DISCUSSION

Overview

General Information

Member Armijo asked about components that are made of low-alloy steel, as opposed to stainless steel. Mr. Davis replied that the reactor vessel, pressurizer, steam generator, and the steam generator shell are made of low-alloy steel. In new plants, the steam and feed system components may be made of 1.25 wt.% Cr and 2.25 wt.% Cr steels for flow-accelerated corrosion resistance.

[pp. 10-11 in transcript, slide 3 in presentation]

Member Bley asked if applicants followed these RGs, as opposed to proposing other methods to meet the regulations. Mr. Stevens said that the postweld bakeout procedure in RG 1.50 was reviewed and approved by the staff before it was included in the RG. Mr. Davis said the only

exception to these RGs in the past has been the postweld hydrogen bakeout, which is now formally included in the document.

[pp. 13-14 in transcript, slide 5 in presentation]

RG 1.34: Control of Electroslag Weld Properties

Chairman Armijo asked about the components that are fabricated with electroslag welding. Mr. Davis said that it is used to fabricate supports but not vessels. Ring sections for vessels will be fabricated with submerged arc welding, not electroslag welding. Mr. Honcharik stated that electroslag welding was more conducive for longitudinal welds in vessels from plate material.

[pp. 15-17 in transcript, slide 6 in presentation]

Member Sieber asked whether electroslag welds made 30-50 years ago posed any unique problems for plant life extension. Mr. Honcharik stated that most of the embrittlement problems are due to copper addition. Flaws in electroslag welds are typically subsurface, so they do not grow. Applicants have to meet upper shelf energy requirements for license renewal. Mr. Davis said that the supports addressed here refer to vessel supports, steam generator supports, and pressurizer supports. Mr. Stevens stated that ultrasonic inspections have revealed no indications in electroslag welds. Embrittlement issues are being managed with regulations. Member Shack mentioned that the updated pressurized thermal shock calculations may have used a different flaw distribution for electroslag welds.

[pp. 17-20 in transcript, slide 6 in presentation]

RG 1.43: Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components

Chairman Armijo asked about underclad cracks. Mr. Davis stated that fine-grained material is being used for the new plant designs, such that plant owners do not have to do the additional metallurgical testing to qualify the welds. So, underclad cracking is not expected to be an issue. Mr. Riechelt said that these RGs were developed in the 1970s, when undercald cracking was a problem. Standard practice today is to use fine-grained materials. Chairman Armijo asked whether the vessel forgings will meet the fine-grained material specifications. Mr. Davis replied that they will use American Society of Testing and Materials grain size number 5 or finer. Some design centers list this specification in the design certification.

[pp. 21-24 in transcript, slide 7 in presentation]

RG 1.44: Control Processing and Use of Stainless Steel

Chairman Armijo asked whether the use of sensitized stainless steel was prohibited. Mr. Davis stated that most reactor designs will use stainless steels with less than 0.03 wt.% carbon. For designs that do not, they must perform post-weld heat treatment and/or provide sufficient information to demonstrate that sensitization will not occur. Member Shack pointed out that the guidance allowed for the use of sensitized material even when the oxygen content of the coolant environment is in the 100 parts per billion (ppb) range. He pointed out that 20 ppb would be more consistent with laboratory test data and operating experience.

[p. 26 in transcript, slide 9 in presentation]

Member Rempe asked about the reasons behind avoiding acid pickling of stainless steels. Mr. Stevens stated that acid pickling can lead to hydrogen cracking. Chairman Armijo stated that pickling can initiate intergranular corrosion before the material is in service, creating a site for

future stress corrosion. Use of sensitized stainless steel has caused extensive problems in the past, and modern nuclear plants should not be built with sensitized material. Extensive discussion centered on whether this guidance provides enough discouragement on the use of sensitized stainless steel in new BWR or PWR plants. Mr. Stevens noted that SCC involves three factors: stress, environment, and susceptible material. If one factor is removed, then SCC will not occur. This guidance discusses the material. Dr. Armijo disagreed and pointed out that it is extremely difficult to assure that stress is sufficiently low and that the coolant environment is always benign, consequently the best protection against stress corrosion is the use of inherently resistant materials.

[pp. 27-30 in transcript, slide 9 in presentation]

RG 1.50: Control of Preheat Temperature for Welding of Low Alloy Steel

Chaiman Armijo asked about the applications of this RG. Mr. Davis stated that RG 1.50 would apply to welding of reactor vessels and some safety-related systems that use 1.25 and 2.25 wt. % Cr steels. Chairman Armijo asked about detection of cold cracks. Mr. Davis stated that the cracks would be detected during nondestructive testing required to accept the weld for service. If cracking is detected, then it must be repaired since it creates potential for future problems.

[pp. 31 in transcript, slide 10 in presentation]

Need for Changes

Chairman Armijo asked whether any interim staff guidance was issued between the initial publication of these RGs and the revision. Mr. Reichelt stated that interim guidance was not likely issued. These guides are more useful for someone new to welding, since those experienced in the field would know the issues raised in the guides are good practices. Chairman Armijo asked whether these guides applied to weld overlays implemented for repairing cracks. Mr. Davis said that the guidance on stainless steel sensitization applied to that situation. Many techniques to reduced heat input were executed. Mr. Stevens said that weld overlays followed ASME Code Cases. Chairman Armijo said that inlays may present a more serious case, as the sensitization would be on the inside of the pipe.

[pp. 33-36 in transcript, slide 11 in presentation]

Revision Timeline

Chairman Armijo asked about Nuclear Fabrication Consortium's request to delay publication of the guidance. Mr. Csontos responded that they had a large grant to look at issues at future plants. They wanted to delay issuance of the RGs until their program was complete. If they find something new in the future, they can contact the NRC to request further revisions to the guides. Chairman Armijo said that they can always obtain approval to depart from approved guidance.

[pp. 38-40 in transcript, slide 12 in presentation]

Technical Revision Summary

RG1.43: Control of Stainless Steel Weld Cladding of Low Alloy Steel

Chairman Armijo asked about the destructive metallographic examination. Mr. Davis stated that it was completed during the procedure qualification, along with other tests required by ASME Code Sections III and IX. Chairman Armijo pointed out that nondestructive testing was not

useful and that the procedure qualification is the sole control to avoid underclad cracking. Mr. Davis agreed that the flaws could not be detected by nondestructive testing. However, it is more likely that a licensee would use fine-grained material, rather than rely on the procedure qualification.

[pp. 43-45 in transcript, slide 15 in presentation]

RG 1.44: Control of Processing and Use of Stainless Steel

Chairman Armijo commented that the RG was too focused on avoiding sensitization, rather than on using inherently sensitization-resistant (low-carbon) stainless steel. Mr. Davis said that BWRs and PWRs should be considered separately. For BWRs, NUREG-0313 recommends materials to use, and 0.02 wt % carbon stainless steels are being used in the designs reviewed so far. For PWRs, if the dissolved oxygen content is below a specific level, then low carbon stainless steel is not required. Chairman Armijo said that he is concerned because of recent stress corrosion cracking in stainless steel welds in PWRs. Off-normal water chemistry can occur and cause problems. Member Shack stated that the 100 ppb threshold in RG1.44 is too high, according to available stress corrosion data. The data support 20 ppb. Chairman Armijo pointed out that controlling the material used to build a plant is more reliable than controlling water chemistry over 40-60 years of operation. Controlling residual stresses is difficult because of the numerous variables in component geometry, welders, and weld and weld repair processes. The use of high carbon stainless steel should not be acceptable in the RG. Mr. Stevens responded that Regulatory Position 4.a would require licensees/applicants to use low carbon materials in BWRs, since no one can guarantee the effectiveness of hydrogen water chemistry. Chairman Armijo said that BWRs should use both hydrogen water chemistry and low carbon material. Member Shack said that PWRs are the concern. There is no practical reason to use sensitized stainless steel. A 20 ppb limit would be more difficult to achieve in the entire system. While the use of sensitized stainless steel may not be a safety issue, it could lead to operational problems. Mr. Davis stated that corrosion testing was required for materials over 0.03 wt % carbon. Chairman Armijo replied that materials may pass the acid test and still crack in service. Mr. Csontos said that the staff may reconsider this issue and obtain alignment with the Office of Nuclear Reactor Regulation. Member Shack stated that the RG should have the best engineering solution. If the licensee/applicant wants to use sensitized material, then they have to make a good argument. Mr. Honcharik stated that the new designs have been changed to ensure that stagnant conditions leading to unfavorable chemistry do not exist. Low carbon stainless steel can crack, especially if cold work is present.

[pp. 46-59 in transcript, slide 16 in presentation]

RG 1.50: Control of Preheat Temperature for Welding of Low Alloy Steel

Chairman Armijo wondered whether the control of preheat temperature was required for fine-grained material. Mr. Davis clarified that this guide addresses pressure boundary structural welds, rather than cladding. For cladding, preheat controls would be found in Section IX of the ASME Code.

[pp. 61-62 in transcript, slides 17-18 in presentation]

Public Comments

Member Bley asked about a “PQR.” Mr. Reichelt stated that a PQR is procedure qualification record. The ASME Code allows many welding procedure specifications (WPSs) to be generated from one PQR. But, the intent of the requirement in RG 1.34, Position 4 was to limit one WPS for one PQR.

[pp. 68-69 in transcript, slides 19-41 in presentation]

Member Rempe asked about ensuring that public comments were appropriately addressed. Mr. Stevens said that informal discussion of the comments may take place with the commenter.

[pp. 88-90 in transcript, slides 19-41 in presentation]

Summary and Conclusion

Chairman Armijo asked whether the Members had any specific comments. Member Shack said that RG 1.44 should be changed to reflect the fact that the 100 ppb dissolved oxygen limit is not technically defensible for sensitized stainless steels. Chairman Armijo stated that licensees/applicants wanting to use sensitized stainless steel should pass a high level of scrutiny. This issue may resurface at the Full Committee meeting. Chairman Armijo gave the staff advice on preparing for the Full Committee meeting, and Mr. Hardies obtained clarification on the issue of allowing the use of sensitized stainless steel.

[pp. 93-98 in transcript, slide 42 in presentation]