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DRAFT REGULATORY GUIDE

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DRAFT REGULATORY GUIDE DG-1223

(Proposed Revision 1 of Regulatory Guide 1.34, dated December 1972)

CONTROL OF ELECTROSLAG WELD PROPERTIES

A. INTRODUCTION

General Design Criterion 1, "Quality Standards and Records," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," of the *Code of Federal Regulations* (10 CFR Part 50) requires that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed. Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 requires that measures be established to ensure materials control and control of special processes such as welding and that proper testing be performed. This guide describes an acceptable method of implementing these requirements with regard to the control of weld properties when fabricating electroslag welds for nuclear components made of ferritic or austenitic materials. This guide applies to light-water reactors.

The U.S. Nuclear Regulatory Commission (NRC) issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required.

This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received final staff review or approval and does not represent an official NRC final staff position.

Public comments are being solicited on this draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rulemaking, Directives, and Editing Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; e-mailed to nrcrep.resource@nrc.gov; submitted through the NRC's interactive rulemaking Web page at http://www.nrc.gov; or faxed to (301) 492-3446. Copies of comments received may be examined at the NRC's Public Document Room, 11555 Rockville Pike, Rockville, MD. Comments will be most helpful if received by August 31, 2009.

Electronic copies of this draft regulatory guide are available through the NRC's interactive rulemaking Web page (see above); the NRC's public Web site under Draft Regulatory Guides in the Regulatory Guides document collection of the NRC's Electronic Reading Room at http://www.nrc.gov/reading-rm/doc-collections/; and the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under Accession No. ML090750626.

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Background

The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, "Nuclear Power Plant Components,"[1] specifies certain requirements associated with manufacturing Class 1 and 2 components.

Procedure Qualifications

Section III requires adherence to ASME Boiler and Pressure Vessel Code, Section IX, "Welding Qualifications," which includes the requirements for the procedure qualification for welds. Review of the requirements of the procedure qualification stated in Section IX indicates that supplementary requirements are desirable to provide assurance of adequate weld metal properties when the electroslag welding process is used. The assurance of satisfactory electroslag welds for low-alloy steel and stainless steel can be increased by maintaining a weld metal solidification (dendritic) pattern with a strong intergranular bond in the center of the weld. 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 metal solidification pattern. If the combination of process variables results in a deep pool of molten weld metal, the crystalline (dendritic) growth direction from the pool sides will join at an obtuse angle in the center of the weld, and cracks may develop because of the weaker centerline bond between dendrites. Section I-I in Figure A of this guide illustrates the dendritic growth pattern. A combination of process variables resulting in a shallow pool of molten weld metal will promote a dendritic growth pattern with an acute joining angle and will result in a strong centerline bond. Acceptable welds should show a dendritic freezing pattern with a joining angle of less than 90 degrees in the weld center.

Tests should be made to ensure that the acceptable weld metal solidification pattern specified above is obtained and that unacceptable patterns will not result. The use of a macro-etch examination is a satisfactory technique to determine the weld solidification pattern, and it should be included in the procedure qualification.

[1] Copies of ASME standards discussed herein may be obtained from the American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990; telephone (800) 843-2763; http://www.asme.org/Codes/Publications//.

Production Welds

The procedure qualification by itself does not ensure that low-alloy steel production welds will meet the weld solidification pattern and mechanical property requirements specified in the procedure qualification. To ensure that welds do comply, it is necessary that the production welds themselves be examined.

Where the electroslag welding process is used for longitudinal welds in low-alloy steel vessels, it is customary to continue the welding process into prolongations to the base metal. These prolongations contain both base metal and weld metal and provide representative samples for testing the mechanical properties of the base metal and the weld metal. The weld solidification pattern can be determined from weld samples taken from these prolongations. A macro-etch test on a weld center sample taken across the weld from base metal to base metal in the direction of the weld progression, as shown in Figure A of this guide, would be an acceptable method of verifying that the specified solidification pattern has been obtained, and this test should be made. An acceptable alternative to the macro-etch test for ensuring the soundness of the center weld metal would be to perform an impact test with the specimen notch located at the weld center as shown in Figure A.

Section III requires that material having its mechanical properties enhanced by a heat treatment must subsequently be tested to ensure the effectiveness of the heat treatment. To provide this assurance for low-alloy steel electroslag production welds, the mechanical properties of the weld metal should be determined from the weld prolongation by tests similar to those required for the quenched and tempered base metal. For Class 2 vessels, it would not be necessary to test all electroslag weld seams, but at least one weld should be tested for each shell course.

Industry experience with electroslag welded stainless steel components has shown that cracking in the weld solidification region is not a problem when the process is properly qualified and controlled. In addition, the weld metal structure and mechanical properties are generally acceptable. To ensure that the production welds are satisfactory, the welding process variables specified in the procedure qualification should be monitored during the welding process.

C. REGULATORY POSITION

Electroslag weld fabrication for core support structures and Class 1 and 2 vessels and components should comply with Section III and Section IX of the ASME Boiler and Pressure Vessel Code, supplemented by the following:

1. The procedure qualification for low-alloy steel and stainless steel welding should require the following:
   a. Process variables such as slag pool depth, electrode feed rate and oscillation, current, voltage, and slag conductivity should be selected to produce a solidification pattern (dendritic grain pattern) with a joining angle of less than 90 degrees in the weld center.
   b. A macro-etch test should be performed in the longitudinal weld direction of the center plane across the weld from base metal to base metal as shown in Figure A of this guide. The test should verify that the desired solidification pattern resulting from Regulatory Position l.a above has been obtained and that the weld is free of unacceptable fissures or cracks.

2. The certified qualification test report should include the results of the tests required by Regulatory Position 1 above.

3. For longitudinal production welds of low-alloy steel vessels, material containing base metal and weld metal taken from weld prolongations should be tested as follows:

a. Tensile and impact tests similar to those required for the base metal by paragraph NB-3211(d) of Section III of the ASME Boiler and Pressure Vessel Code should be made to determine the mechanical properties of the quenched and tempered weld metal.

b. To verify that the specified weld solidification pattern has been obtained and that the weld center is sound, one of the following methods should be used:
   (1) a macro-etch test similar to that described in Regulatory Position 1.b above, or
   (2) impact testing with the specimen notch located at the weld center as shown in Figure A of this guide.

c. The tests specified in Regulatory Positions 3.a and 3.b above should be applied to the following:
   (1) each of the welds for Class 1 vessels, and
   (2) one weld per shell course for Class 2 vessels.

4. For production welds for austenitic stainless steel core support structures and fluid system components, the production welding should be monitored to verify compliance with the limits for the process variables specified in the procedure qualification.

5. If properties obtained from tests identified in Regulatory Positions 3 and 4 above are not acceptable, additional procedure qualifications should be performed in accordance with Regulatory Position 1 above.

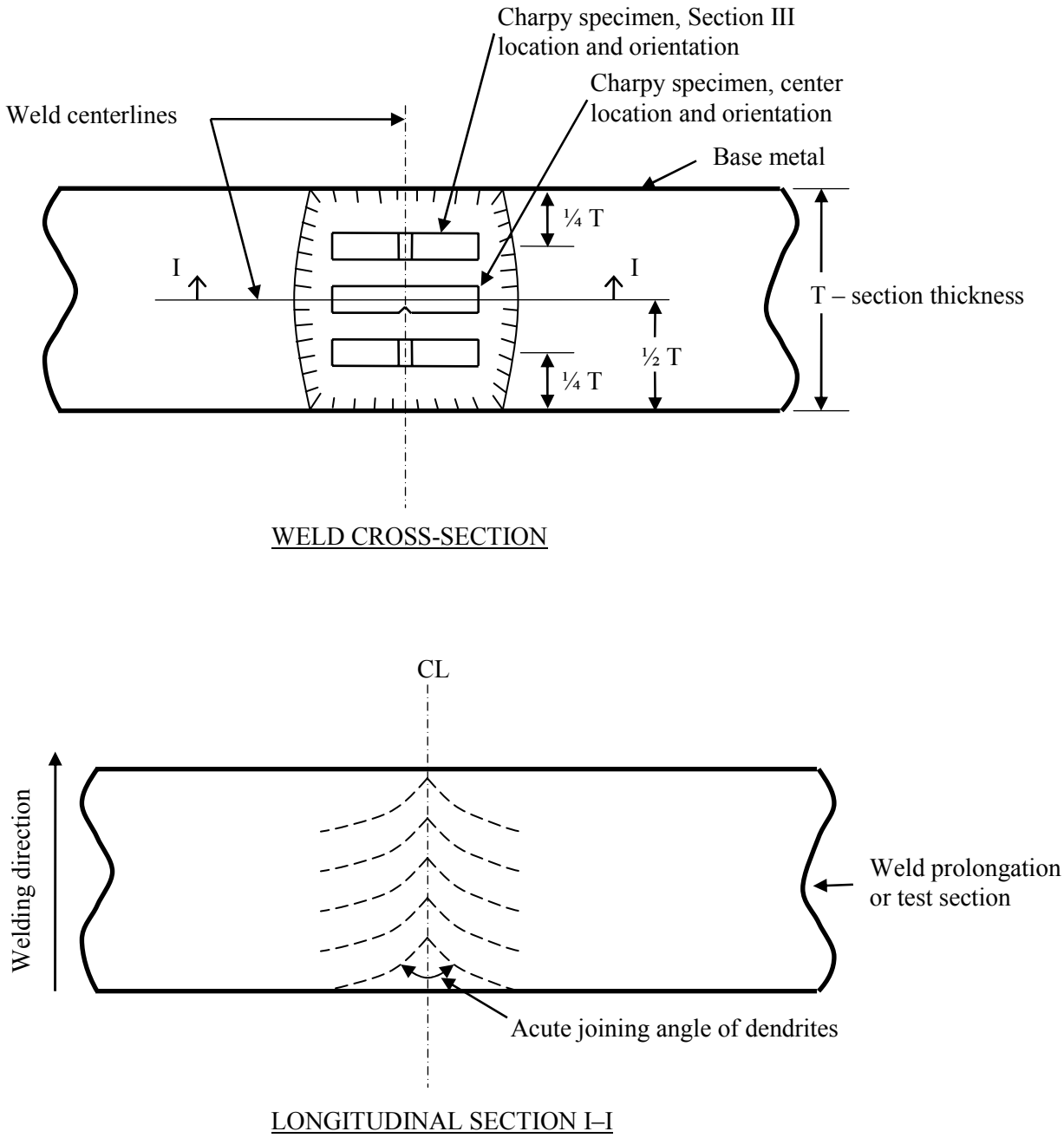

Figure A: Weld cross-section showing solidification pattern and Charpy test specimen

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this draft regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. The NRC will consider all public comments received in development of the final guidance document. In some cases, applicants or licensees may propose an alternative or use a previously established acceptable alternative method for complying with specified portions of the NRC's regulations. Otherwise, the methods described in this guide will be used in evaluating compliance with the applicable regulations for license applications, license amendment applications, and amendment requests.

REGULATORY ANALYSIS

Statement of the Problem

The NRC initially issued Regulatory Guide 1.34, "Control of Electroslag Weld Properties," in December 1972. The guidance does not reflect changes in the ASME Boiler and Pressure Vessel Code since 1972. Therefore, revision of this regulatory guidance is necessary to reflect updates in the ASME Code.

Objective

The objective of this regulatory action is to update the NRC's guidance for the control of electroslag weld properties, consistent with changes in the ASME Code since December 1972.

Alternative Approaches

The NRC staff considered the following alternative approaches:

Do not revise Regulatory Guide 1.34.
Revise Regulatory Guide 1.34.

<u>Alternative 1: Do Not Revise Regulatory Guide 1.34</u>

Under this alternative, the NRC would not revise the guidance, and the current guidance would be retained. If the NRC does not take action, there would not be any changes in costs or benefit to the public, the licensees, or the NRC. However, the "no-action" alternative would not address identified concerns with the current version of the regulatory guide. The NRC would continue to review each application on a case-by-case basis. This alternative provides a baseline condition from which any other alternatives will be assessed.

<u>Alternative 2: Revise Regulatory Guide 1.34</u>

Under this alternative, the NRC would revise Regulatory Guide 1.34, taking into consideration the changes in the ASME Code.

One benefit of this action is that it would clarify the guidance and references to the ASME Code for applicants building new nuclear power plants, as well as for licensees.

The impact to the NRC would be the costs associated with preparing and issuing the regulatory guide revision. The impact to the public would be the voluntary costs associated with reviewing and providing comments to the NRC during the public comment period. The value to the NRC staff and its applicants would be the benefits associated with enhanced efficiency and effectiveness in using a common guidance document as the technical basis for license applications and other interactions between the NRC and its regulated entities.

Conclusion

Based on this regulatory analysis, the NRC staff recommends revision of Regulatory Guide 1.34. The staff concludes that the proposed action will reduce unnecessary confusion when referencing the ASME Code. It could also lead to cost savings for the industry, especially with regard to applications for standard plant design certifications and combined licenses.