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REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

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PREHEAT AND INTERPASS TEMPERATURE CONTROL FOR THE WELDING OF LOW–ALLOY STEEL FOR USE IN FUEL REPROCESSING PLANTS AND IN PLUTONIUM PROCESSING AND FUEL FABRICATION PLANTS

A. INTRODUCTION

Section 50.34, "Contents of Applications; Technical Information," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires, among other things, that each application for a construction permit or operating license for a fuel reprocessing plant include a discussion of how the applicable requirements of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 will be satisfied. As used in Appendix B, "quality assurance" comprises all those planned and systematic actions necessary to provide adequate confidence that safety-related structures, systems, and components will perform satisfactorily in service. Appendix B requires, in part, that measures be established to ensure that special processes, including welding, are controlled and accomplished by qualified personnel using qualified procedures, and that proper process monitoring be performed. Paragraph 70.22(f) of 10 CFR Part 70, "Special Nuclear Material," requires that each application for a license to possess and use special nuclear material in a plutonium processing and fuel fabrication plant contain a description of the quality assurance program to be applied to the design, fabrication, construction, testing, and operation of the structures, systems, and components of the plant and that the description include a discussion of how the criteria of Appendix B to Part 50 will be met. Paragraph 70.23(b) of 10 CFR Part 70 provides that the Commission will approve construction of a plutonium processing and fuel fabrication plant when it has determined that the design bases and the quality assurance program provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents, noting that the criteria in Appendix B to 10 CFR Part 50 will be used by the Commission in determining the adequacy of the quality assurance program.

This guide describes a method acceptable to the NRC staff for meeting these requirements with regard to the control of welding of low-alloy steel components for fuel reprocessing plants and for plutonium processing and fuel fabrication plants.

B. DISCUSSION

The American Society of Mechanical Engineers Boiler and Pressure Vessel Code* (ASME Code), Section III, "Nuclear Power Plant Components," and Section VIII, "Pressure Vessels," specify requirements for fabricating components as indicated in the section titles. Many of the requirements of this Code can also be applied to safety-related structures, systems, and components of fuel reprocessing plants and plutonium processing and fuel fabrication plants. Specific portions of the ASME Code and of other applicable codes and standards have been used for fabricating components for such plants. Acceptable practices can differ significantly because there has not been sufficient guidance toward standardization. In the interest of standardization, this guide specifies procedures acceptable to the NRC staff for the control of preheat and interpass temperatures for welding of low alloy steels for use in the plants discussed above. These procedures, which draw on those used for nuclear power plants, will provide a uniform quality level consistent with the function of safety-related structures, systems, and components of fuel reprocessing plants and of plutonium processing and fuel fabrication plants.

*American Society of Mechanical Engineers Boiler and Pressure Vessel Code, 1974 Edition. All references to the ASME Code are to the 1974 edition. Copies may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017.

Procedure Qualification

Section III and Section VIII require adherence to Section IX, "Welding and Brazing Qualifications," of the ASME Code, including the requirements governing procedure qualifications for welds. Review of the requirements of Section IX for procedure qualifications and the fabrication requirements of Sections III and VIII indicates the desirability of supplementary requirements to ensure adequate control of welding variables in the production welding of low-alloy steels.

The assurance of satisfactory welds in low-alloy steels can be increased significantly and, in particular, the propensity for cracks (cold cracks) or reheat cracks forming in underbead areas and heat-affected zones (HAZ) can be minimized by maintaining proper preheat temperatures on the base metals concurrent with controls on other welding variables.

Cold cracking can occur when the steel is hardened; i.e., undergoes a phase transformation to martensite in the HAZ and/or weld metal. The martensite exhibits brittle fracture tendencies, and it may not be able to withstand rapid cooling and the volume change associated with the phase transformation without the occurrence of local cracking. This susceptibility to cracking increases with higher stresses, such as those experienced with increased thickness or welding under constraint of the parts being welded, and also increases with a decrease in welding energy input. In order to avoid or minimize the effects of hardening associated with phase transformation, a longer cooling time is needed for the weld; in other words, the preheat temperature should be maintained high enough to achieve an acceptable condition of the phase transformation.

It is generally recognized that atomic hydrogen absorption and diffusion into and through the region being welded have an important influence on the tendency to form cracks. While the level of hydrogen in weld filler metal is low enough to preclude adverse effects in the welds, greater quantities of hydrogen can be present in the weld region from the dissociation of moisture in hygroscopic welding fluxes or adsorbed on metal surfaces if the welding fluxes and surfaces have not been properly dried before weld deposition. Embrittlement of metal in the weld area due to the presence of hydrogen generally occurs at lower temperatures and may be prevented by prolonging the time the weldment is maintained at preheating temperature or by performing a postweld heat treatment. Prolonged time at preheating can prevent or interrupt local hardening and assist in reducing adverse effects of a potential hydrogen gradient. This gradient would disappear by means of diffusion of the hydrogen before the weldment is returned to room temperature. Therefore, the minimum preheat temperature should be established to ensure a desirable cooling rate for the weld, and this temperature should be maintained until a postweld heat treatment has been achieved.

In addition to the minimum preheat temperature, a maximum interpass temperature should be specified. If the weld metal should transform at too high a temperature, the required mechanical properties for the metal may not be met. The maximum interpass temperature varies for different steels, as does the minimum preheat temperature, and should be selected on the basis of such influencing factors as the chemical composition of the steel.

Production Welds

The procedure qualification by itself does not ensure that the production welds will be made within the specified preheat temperature range. To ensure that the welds will be acceptable, the metal temperature should be monitored during the welding process and through postweld heat treatment.

C. REGULATORY POSITION

Weld fabrication* for low-alloy steel components important to safety should comply with acceptable fabrication requirements and should be performed by qualified welders and welding procedures in accordance with the requirements of Section IX of the ASME Code supplemented by the following:

1. The procedure qualification should require that:

   a. A minimum preheat and a maximum interpass temperature be specified.

   b. The welding procedure be qualified at the minimum preheat temperature.

2. For production welds, the preheat temperature should be maintained until a postweld heat treatment has been performed.

3. Production welding should be monitored to verify that the limits on preheat and interpass temperatures are maintained.

4. In the event that regulatory positions C.1, C.2, and C.3 above are not met, the weld is subject to rejection. However, the soundness of the weld may be verified by an acceptable examination procedure.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for utilizing this regulatory guide.

*Applies also to welding and weld repairs after initial fabrication when a postweld stress-relieving heat treatment is used.

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 in the evaluation of submittals in connection with applications for permits and licenses docketed after November 3, 1975.

For those applications docketed on or before November 3, 1975, the NRC staff may reevaluate the application on a case-by-case basis to ensure that acceptable weld qualification and production welding procedures are being used.

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