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REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 3.27

NONDESTRUCTIVE EXAMINATION OF WELDS IN THE LINERS OF CONCRETE BARRIERS IN FUEL REPROCESSING 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, heat treating, and nondestructive testing, be controlled and accomplished by qualified personnel using qualified procedures.

The leaktight integrity of metal liners of concrete confinement barriers is an important consideration in safety evaluations. The methods described in this guide are the most recent general approaches acceptable to the NRC staff for handling the problem and reflect the results of staff review and action on specific cases. If new information that may be developed in the future results in alternative methods, such methods will be reviewed by the staff to determine their acceptability.

B. DISCUSSION

Metal liners of confinement systems in fuel reprocessing plants keep radiochemicals from contaminating the environs. Because their leaktight integrity is an important consideration in the safety evaluation of fuel reprocessing plants, through-thickness cracks in these liners are unacceptable. Surface cracks and other weld defects that can hold up radioactive solutions or particulates may complicate decontamination of the liners for decommissioning or when direct repair, maintenance, or inspection of the liner or of other components within the liner must be made. They can also cause leakage of the liner by initiating accelerated crevice corrosion by either the operation or decontamination environment. These surface cracks and weld defects, therefore, should be avoided.

The leaktight integrity of confinement barrier liners should be confirmed by examination. Many acceptable nondestructive testing methods and procedures are available and have been used for the nondestructive examination of liner welds. These practices have differed significantly because there has not been sufficient guidance toward standardization. This guide standardizes procedures acceptable to the NRC staff for the nondestructive examination of liner welds. These procedures, which draw on those used for nuclear power plants, will provide a uniform quality level consistent with the safety function of confinement barrier liners in fuel reprocessing plants.

C. REGULATORY POSITION

The following criteria delineate the latest general approaches acceptable to the NRC staff. An applicant who desires to use an alternative method based upon newly developed information may do so after the NRC staff reviews the proposal and if it approves the method as acceptable for use.

Welds in the metal liners of concrete confinement barriers in fuel reprocessing plants should be nondestructively examined using the following methods:

1. Nondestructive Examination Methods for Liner Seam Welds

*Lines indicate substantive changes from previous issue.

a. For each welder and welding position (flat, vertical, horizontal, and overhead), the first 10 feet of weld and a minimum of one spot (not less than 12 inches in length) in each additional 50-foot increment of weld (weld test unit) or fraction thereof should be examined radiographically.

b. Where radiographic examination of liner seam welds is not feasible or where the weld is located in an area that will not be accessible after the construction of the confinement barrier, the entire length of weld should be examined by the ultrasonic method or the magnetic-particle method for magnetic welds or by the ultrasonic method or the liquid-penetrant method for nonmagnetic welds.

c. All liner seam welds should be tested for leaktightness by the vacuum box method, by the halogen diode method, or by the helium mass spectrometer method (or by other methods of equivalent sensitivity).

d. Where leak-chase-system channels are installed over liner welds, channel-to-liner-plate welds should be tested for leaktightness by pressurizing the channels to a minimum pressure of 25-psi gauge. If any indicated loss of channel test pressure occurs within 2 hours, as evidenced by a test gauge that meets the requirements of NB-6400 of Section III of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code* (ASME Code), the channel-to-liner welds should be leak tested by one of the methods specified in regulatory position 1.c above.

2. Nondestructive Examination Methods for Penetration, Airlock, and Access Opening Welds

a. All welds in penetrations, airlocks, and access openings that are not backed by concrete, such as welds between penetrations and flued fittings and between flued fittings and pipelines, should be fully examined in accordance with the examination methods of NE-5200 of Section III of the ASME Code. Procedures and techniques that should be used for these examination methods are given in regulatory position 3 of this guide.

b. All welds in the vicinity of penetrations, airlocks, and access openings that are backed by concrete, such as welds between penetration and reinforcing plate,** penetration and liner, reinforcing plate and liner, liner insert and liner, reinforcing plate and frames for airlocks and access openings, and liners and frames for airlocks and access openings, should be fully examined (1) in accordance with regulatory position 2.a above or (2) by the magnetic-particle method for magnetic welds or the liquid-penetrant method for nonmagnetic welds.

c. All welds in bellows-type expansion joints provided in penetration assemblies should be tested by the magnetic-particle method for magnetic welds or by the liquid-penetrant method for nonmagnetic welds.

3. Nondestructive Examination Procedures and Techniques

a. Radiographic examination should be performed in accordance with the techniques and requirements of Articles 1 and 2 of Section V, "Nondestructive Examination," of the ASME Code.

b. Magnetic-particle examination should be performed in accordance with Articles 1 and 7 of Section V of the ASME Code.

c. Ultrasonic examination should be performed in accordance with Articles 1 and 5 of Section V of the ASME Code.

d. Liquid-penetrant examination should be performed in accordance with Articles 1 and 6 of Section V of the ASME Code.

e. Leak testing by the vacuum box method should be performed in accordance with Article 1 of Section V of the ASME Code and Appendix A to this guide. Leak testing by the halogen diode method should be performed in accordance with Articles 1 and 10 of Section V of the ASME Code. Leak testing by the helium mass spectrometer method should be performed in accordance with Articles 1 and 10 of the Section V of the ASME Code.

4. Qualifications of Nondestructive Examination Personnel

Nondestructive examination should be performed by personnel designated by the licensee or his agent and qualified in accordance with the provisions of Article 1, and other applicable articles for the particular test method used, of Section V of the ASME Code.

5. Selection of Spots for Radiographic Examination

The spots of liner seam welds to be radiographically examined should be randomly selected, but no two spots in adjacent weld test units should be closer together than 10 feet. Locations of examined spots should be recorded.

* American Society of Mechanical Engineers Boiler and Pressure Vessel Code, 1974 Edition including the 1975 Winter Addenda. All references to the ASME Code are to the 1974 Edition including the 1975 Winter Addenda. Copies may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017.

** Thickened liner insert that provides local reinforcement.

6. Time of Examination

All examinations should be performed as soon as practicable after completion of the lineal increment of weld to be examined. If postweld heat treatment is required, examinations should be performed as soon as practicable after the heat treatment.

7. Postexamination Cleaning

Following each procedure in which examination materials remain on the surface, the surface should be cleaned in accordance with the requirements for the finished liner.

8. Acceptance Standards

The requirements of Section III, Division 2 CC-5000 of the ASME Code should be followed.

9. Repair and Reexamination

The requirements of Section III, Division 2 CC-5000 of the ASME Code should be followed.

10. Records

Records of radiographs and other nondestructive examinations, including those for repaired defective welds, should be retained by the licensee in compliance with the provisions of Criterion XVII, "Quality Assurance Records," of Appendix B to 10 CFR Part 50.

APPENDIX A

VACUUM BOX EXAMINATION OF LINER SEAM WELDS

1. Scope: This appendix gives the procedure and requirements for examination of welds by the vacuum box method. Much of the information presented is adapted for this test method from different parts of Section V of the ASME Code.

2. Applications; The vacuum box examination method allows through-thickness indications such as leaks, pores, and the lack of fusion in welds to be detected. The method does not allow for quantitative determinations, but the presence of leaks and their positions can be determined. A bubble-forming solution is applied to the weld, and a vacuum box with a viewing window is placed over the area to be tested. The box is evacuated, and through-thickness leaks are detected by the formation of bubbles on the surface.

3. Written Procedure: The vacuum box test examination should be performed to detailed written procedures in accordance with Article 1 of Section V of the ASME Code and with the applicable requirements of this appendix.

4. Personnel Qualification: Personnel performing leak testing by the vacuum box method should be qualified in accordance with the requirements of Article 1 of Section V of the ASME Code.

5. Procedure: The following procedure should be used for weld examination by the vacuum box method:

   a. Surface Preparation (Adapted from Article 6, Section V, ASME Code). Satisfactory results are obtained when the surface is in the as-welded condition. The surface to be examined should be free of any dirt, grease, paint, scale, welding flux, weld spatter, slag, or other material that could otherwise interfere with the examination or the interpretation of the test results. Cleaning may be accomplished by wire brushing with a stainless steel brush or by the use of cleaning agents such as detergents, organic solvents, descaling solutions, and paint removers. Cleaning solvents should meet the requirements of T-630(b) of Article 6 of Section V of the ASME Code. Drying, after cleaning, of the surfaces to be examined should be accomplished by normal evaporation or with forced hot air, as appropriate. A minimum period of time should be established and included in the procedure to ensure that the cleaning solution has evaporated prior to application of the bubble-forming solution.

   b. Bubble Solution. The bubble-forming solution should produce a film that does not break away from the area to be tested, and the bubble formed should not break rapidly due to air drying or low surface tension. The number of bubbles contained in the solution should be minimized to reduce the problem of discriminating between existing bubbles and those caused by the test. Ordinary household soap or detergent should not be permitted as substitutes for bubble-testing solutions in which, in principle, a bubble will form when there is leakage present. (The above description is taken from Article 6, Section V, ASME Code.) The test solution should be checked every hour with a suitable test leak to verify the bubble formation property of the solution used.

   c. Application of Solution: The bubble-forming solution is applied to the low-pressure side of the surface to be examined. The entire test area should be evenly coated by flowing the solution over it. The temperature of the surface to be examined should be in the range of 40° to 100°F. The solution should be applied immediately before the test, not more than 1 minute before testing.

   d. Vacuum Test. A vacuum box containing a viewing window is placed over the area to be tested and evacuated to produce at least 5-psi differential with the atmospheric pressure. The 5-psi differential in pressure should be verified by the use of a calibrated gauge and maintained for a minimum of 20 seconds. Leaks in welds, if present, are detected by formation of bubbles. An overlap of 2 inches should be used for each additional examination along the seam weld.

   e. Visual Examination. (T-1032-3 of Article 10, Section V, ASME Code). When performing the visual examination, access to the area to be viewed should permit placing the eye within at least 24 inches of the surface to be examined, at an angle of no less than 30 degrees with the surface to be examined. Mirrors may be used to improve the angle of vision, and aids such as magnifying lenses may be used to assist examinations. Natural or artificial lighting may be used to illuminate the area to be examined. The lighting in the area to be examined should be a minimum of 350 lux (32.5 footcandles).

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