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U. S. Nuclear Regulatory Commission
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Donald C. Cook Nuclear Plant Units 1 and 2
NUCLEAR REGULATORY COMMISSION BULLETIN 2004-01
INSPECTION OF ALLOY 82/182/600 MATERIALS USED IN THE FABRICATION OF PRESSURIZER PENETRATIONS AND STEAM SPACE PIPING CONNECTIONS AT PRESSURIZED-WATER REACTORS
SUPPLEMENTAL RESPONSE

In Reference 1 (References are provided at the end of this letter), the Nuclear Regulatory Commission (NRC) requested that pressurized-water reactor licensees provide a description of their plant's pressurizer penetrations and steam space piping connections, a description of their present pressurizer penetration and steam space piping connection inspection program, a description of the pressurizer penetration and steam space piping connection inspection program that will be implemented during the next and subsequent refueling outages, and a discussion of why the future inspection programs are adequate to assure that the reactor coolant system pressure boundary is maintained and applicable regulatory requirements are met.

Indiana Michigan Power Company (I&M) provided the information related to the pressurizer connections and the past and future inspections in Reference 2.

In Reference 1, the NRC also requested licensees to provide pressurizer nozzle inspection results within 60 days following the completion of the next refueling outage. Reference 3 provided the results of inspections performed during the Unit 2, Cycle 15 refueling outage. Based on discussions with the NRC staff during the Unit 1 inspections in April, 2005, it was determined that the discussion of the Unit 2 best effort Performance Demonstration Initiative (PDI) examinations performed during the Unit 2, Cycle 15 refueling outage required further clarification. The following provides both a clarification of the Unit 2 PDI examinations performed during the Unit 2, Cycle 15

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refueling outage and the results of the Unit 1 inspections performed by I&M during the April, 2005, Unit 1, Cycle 20 refueling outage.

Unit 2 Clarification

The Unit 2, Cycle 15 refueling outage examinations were performed using the Electric Power Research Institute (EPRI) PDI procedure, PDI qualified equipment, and PDI qualified personnel. The examinations, however, did not meet all the criteria of the PDI process that would allow the examinations to be credited as PDI-qualified examinations. Additionally, the examinations did not meet the American Society of Mechanical Engineers (ASME) Code, Section XI coverage requirements. The PDI procedure requires the full Alloy 82/182 weld volume to be examined whereas the ASME Code, Section XI requires essentially 100 percent (%) of the inner ⅓ volume to be examined. The PDI and ASME Code, Section XI required coverage was not achievable due to the close proximity of nozzle bosses to the safe ends, weld contours, pipe lugs, and the prohibition by PDI from taking credit for the ultrasonic beam that passes through an austenitic weld prior to passing through dissimilar metal (i.e., Alloy 82/182 buttering). Therefore, no PDI or ASME Code, Section XI completion credit was taken. Since the PDI volume requirement and surface conditions could not be met, the coverage was described as the "inner ⅓ weld volume." This term was used to make a distinction between ASME Code, Section XI coverage requirements and the PDI coverage requirements

Based on the fact that PDI qualified procedures, equipment, and personnel were used to perform the inspections, and noting that all PDI requirements could not be met, the inspections were deemed to be "best effort" PDI examinations.

To address the conditions that make these welds susceptible to primary water stress corrosion cracking (PWSCC) or that preclude achieving the required examination coverage, I&M is developing inspection/mitigation strategies that may include complete weld replacement, extensive surface preparation, mechanical stress improvement, preemptive weld overlays, or a combination of these strategies. Two Unit 2 pressurizer nozzle-to-safe end welds (2-PRZ-24 and 2-PRZ-25) require examination this inspection period to meet ASME Code Section XI, Category B-F percentage requirements. Since one outage remains (Unit 2, Cycle 16) in the current inservice inspection period, adequate planning time exists to ensure that any of the above inspection/mitigation strategies are implemented prior to the end of the current inservice inspection period.

Unit 1 Inspections

Type of Inspection Performed

A bare-metal visual VT-2 and a liquid penetrant examination of all pressurizer Alloy 82/182 locations was completed (there are no Alloy 600 materials connected to the pressurizer). The locations are as follows:

- 1-PRZ-20, Relief Valve Nozzle-To-Safe End
- 1-PRZ-21, Safety Valve Nozzle-To-Safe End
- 1-PRZ-22, Safety Valve Nozzle-To-Safe End
- 1-PRZ-23, Safety Valve Nozzle-To-Safe End
- 1-PRZ-24, Spray Valve Nozzle-To-Safe End
- 1-PRZ-25, Surge Line Nozzle-To-Safe End
- Pressurizer Manway (visual VT-2 only)

Inspection Results

There was no evidence of pressure boundary leakage during the bare-metal VT-2 examination. No relevant indications were observed during the liquid penetrant examination.

Type of Inspection Performed

A best effort PDI Supplement 10 volumetric examination was performed using 45-degree and 60-degree shear (S) as well as 45-degree and 60-degree refracted longitudinal (RL) wave transducers. The examinations performed during Unit 1, Cycle 20 refueling outage did not meet all the requirements of the PDI procedure as PDI requires the full Alloy 82/182 weld volume to be examined (ASME Code, Section XI, by contrast, requires that essentially 100% of the inner ⅓ volume to be examined). Because the PDI volume requirement and surface conditions could not be met, the coverage is described as the "inner ⅓ weld volume" to distinguish between ASME Code, Section XI coverage requirements and the PDI coverage requirements. The examinations that were performed during the Unit 1, Cycle 20 refueling outage have not been credited with meeting either ASME Code, Section XI or PDI requirements because neither the ASME Code, Section XI requirements nor all PDI requirements (transducer size, focal distance, weld contours, and surface conditions) could be met. Additionally, the close proximity of nozzle bosses to the safe ends, pipe lugs, and the PDI prohibition to crediting the ultrasonic beam that passes through an austenitic weld prior to passing through dissimilar metal (i.e., Alloy 82/182 buttering and weld) created additional limitations to achieving 100% coverage of the entire required PDI weld volume.

The following components were volumetrically examined and their volumetric weld coverage is also listed:

- 1-PRZ-20, Relief Valve Nozzle-To-Safe End (3.2% circumferential and 6.6% axial of inner ⅓ weld volume with 45-degree S and RL transducers)
- 1-PRZ-21, Safety Valve Nozzle-To-Safe End (3.2% circumferential and 6.6% axial of inner ⅓ weld volume with 45-degree S and RL transducers)
- 1-PRZ-22, Safety Valve Nozzle-To-Safe End (3.2% circumferential and 6.6% axial of inner ⅓ weld volume with 45-degree S and RL transducers)
- 1-PRZ-23, Safety Valve Nozzle-To-Safe End (3.2% circumferential and 6.6% axial of inner ⅓ weld volume with 45-degree S and RL transducers prior to overlay. After overlay approximately 99.8% required PDI coverage was achieved)
- 1-PRZ-24, Spray Valve Nozzle-To-Safe End (15.7% circumferential and 0.8% axial of inner ⅓ weld volume with 45-degree S and RL transducers)
- 1-PRZ-25, Surge Line Nozzle-To-Safe End (100% circumferential and 30.6% axial of inner ⅓ weld volume with 45-degree S and RL transducers)

To address the conditions that make these welds susceptible to PWSCC or that preclude achieving the required examination coverage, I&M is developing mitigation/inspection strategies that may include complete weld replacement, extensive surface preparation, mechanical stress improvement, preemptive weld overlays or a combination of these strategies. Three pressurizer nozzle-to-safe end welds require examination during this inspection period (1-PRZ-21, 1-PRZ-22, and 1-PRZ-24) to meet ASME Code, Section XI Category B-F percentage requirements. One outage remains (Unit 1, Cycle 21) in the current inservice inspection period, allowing time to ensure that a mitigation strategy is implemented prior to the end of the current inservice inspection period.

Inspection Results

One relevant indication was identified in the Alloy 82/182 weld metal in 1-PRZ-23 during the volumetric examination. The indication was identified during manual ultrasonic (UT) examinations of 1-PRZ-23 performed by a vendor using a qualified PDI dissimilar metal weld ultrasonic examiner. The indication was identified while performing the circumferential scans to the extent possible. The indication was categorized as axial. The indication was determined to be a flaw and was evaluated as being contained in the weld material. However, due to the selected probe beam angle (45 degrees), it was not initially possible to determine if the flaw was connected to the inside surface. Supplemental examinations were performed by the examiner to interrogate the indication using a qualified 35-degree probe and the flaw was evaluated as having a definite connection to the inside surface. The flaw depth was initially estimated to be greater than 60% through-wall using a 60-degree refracted longitudinal beam angle probe.

Representatives from EPRI were contacted to assist in the evaluation of the indication. EPRI personnel performed an evaluation of the weld using qualified equipment and techniques. The indication and surrounding weld material were ultrasonically investigated using the entire complement of search units that were used for the original examination. In addition, 60- and 70-degree longitudinal search units (supplied by EPRI) focused on the outer 25% of the component were used in an effort to fully interrogate the upper regions of the weld above the reported indication and to provide an estimate of the depth of the flaw. The examination surface had been ground in an effort to improve scanning in the area of the recorded indication and all search units maintained adequate contact. After evaluation the following conclusions were made:

1. The indication exhibited characteristics indicative of stress corrosion cracking. Multiple tip signals were observed as the search unit was scanned over the flaw, which indicated that the flaw was branched and contained many facets. Even though the flaw was characterized as "quite branched" there is reasonable assurance that the flaw is axially oriented only. The preliminary evaluation with the detection search units also indicated that the flaw had a considerable through-wall dimension.

2. The 35-degree search unit confirmed that the flaw was clearly connected to the inside surface.

3. Evaluations made with the optimized 60- and 70-degree longitudinal search units revealed strong tip signals in the outer 25% of the weld material. The estimated remaining ligament from the deepest portion of the flaw to the outside surface was measured to be approximately 0.17 inches which equates to a flaw height of approximately 1.23 inches (88% of the total weld thickness) based on a measured thickness of 1.4 inches.

4. Based on the estimated location of the weld, there was reasonable assurance that the indication was wholly contained in the weld material.

In addition to the above, I&M contracted with Westinghouse Electric Company to generate a circumferential flaw tolerance chart for the Unit 1 pressurizer safe end nozzles fabricated with Alloy 82/182 weld material. The flaw tolerance chart defines the maximum allowable circumferential flaw size that permits continued operation for at least one fuel cycle (18 months) in the event that circumferential indications were detected in the other pressurizer nozzles or the inspection technique being used was not able to interrogate the full volume of the welds. A circumferential flaw was determined to be more limiting than an axial flaw. Based on the circumferential flaw tolerance chart generated, a circumferential flaw with an initial flaw depth of 38.8% of the wall thickness with an aspect ratio (flaw length divided by flaw depth) of 10 at any location around the circumference was determined to be acceptable in that it would not exceed the ASME Code, Section XI maximum allowable of 75% through-wall in one fuel cycle.

Based on the flaw tolerance evaluation results and the results of the UT examination, which was able to interrogate the inner ⅓ weld volume at several locations around the weld circumference, it can be concluded that the UT examination would have detected an unacceptable flaw with a depth of 38.8% and an aspect ratio of 10 at any location around the circumference. Therefore, although the inspection technique used was not able to interrogate the full volume of the welds, reasonable assurance exists that the structural integrity of the joints will be maintained for the upcoming fuel cycle.

The 1-PRZ-23 flaw was repaired by the application of a full structural weld overlay (ERNiCrFe-7 material) as allowed by the NRC's verbal approval of I&M's relief request, Reference 4, to use a modified version of Code Case N-504-2. Following the repair, a liquid penetrant and ultrasonic examination of the overlay was performed. There were no indications observed for the liquid penetrant examination. Two small laminar areas (lack of bond) were observed during the ultrasonic examination. The laminar flaws were less than 0.2 square inches and met the acceptance criteria of ASME Code, Section XI, Table IWB-3514-3.

The weld overlay also covered the weld downstream of 1-PRZ-23. This is a stainless steel weld (denoted as 1-RC-9-01F) joining the stainless steel safe end to a stainless steel elbow. During the ultrasonic examination of the structural overlay, an indication was observed in, or very near, the fusion zone of this stainless steel weld. The indication is approximately 0.29 inches in height, located approximately 0.09 inches from the inside diameter. This indication was observed while performing an axial scan looking downstream. Therefore, the indication is characterized as circumferential in nature, but did not have any measurable circumferential extent.

A review of construction radiographs indicated that a repair had occurred in close proximity to this stainless steel weld indication. However, only a density change was observed on the radiograph, with no linear type indication observed. The ultrasonic data from 1977 identified two "spot" indications in the approximate area scanning in the axial downstream direction. Based upon these observations, the indication is classified as a construction flaw.

As presented above, the NRC staff approved the weld overlay for 1-PRZ-23. Stainless steel weld 1-RC-9-01F was not included in the relief request; thus, I&M contracted with Westinghouse Electric Company to perform an ASME Code, Section XI, IWB-3600 analysis. I&M conservatively assigned a circumferential extent of 0.3 inches for the IWB-3600 evaluation. The analysis concluded that the flaw was acceptable for the remaining life of the plant. No repair is necessary.

I&M intends to examine the weld overlay for 1-PRZ-23 and 1-RC-9-01F during the Cycle 21 and Cycle 22 refueling outages as required by Code Case N-504-2.

Type of Inspection Performed

The insulation on the pressurizer upper head was completely removed to facilitate other inspections on the pressurizer. This afforded visual access to the bare-metal carbon steel surfaces.

Inspection Results

The bare metal visual inspection of the pressurizer upper head did not reveal any evidence of boric acid deposits or wastage.

Type of Inspection Performed

Insulation was removed for the examination of the surge line nozzle-to-safe end weld and afforded visual access to portions of the bare-metal carbon steel surfaces of the lower head of the pressurizer.

Inspection Results

The bare metal visual inspection of the pressurizer lower head did not reveal any evidence of boric acid deposits or wastage.

Type of Inspection Performed

A visual VT-2 examination of the entire pressurizer and its Alloy 82/182 welds and steam space components was performed during the reactor coolant system normal operating pressure and temperature visual VT-2 examination required by ASME Code, Section XI with the insulation installed.

Inspection Results

There was no evidence of boric acid leakage.

References:

1. NRC Bulletin 2004-01, "Inspection of Alloy 82/182/600 Materials Used in the Fabrication of Pressurizer Penetrations and Steam Space Piping Connections at Pressurized-Water Reactors," dated May 28, 2004.

2. Letter from Joseph N. Jensen, I&M to NRC Document Control Desk, "Donald C. Cook Nuclear Plant Units 1 and 2, Nuclear Regulatory Commission Bulletin 2004-01, Inspection of Alloy 82/182/600 Materials Used in the Fabrication of Pressurizer Penetrations and Steam Space Piping Connections At Pressurized-Water Reactors, Sixty-Day Response," AEP:NRC:4054-07, dated July 26, 2004.

3. Letter from Daniel P. Fadel, I&M, to NRC Document Control Desk, "Donald C. Cook Nuclear Plant Unit 2 Nuclear Regulatory Commission Bulletin 2004-01, Inspection of Alloy 82/182/600 Materials Used in the Fabrication of Pressurizer Penetrations and Steam Space Piping Connections at Pressurized-Water Reactors, Supplemental Response," AEP:NRC:5054, dated January 6, 2005.

4. Letter from Daniel P. Fadel, I&M, to NRC Document Control Desk, "Donald C. Cook Nuclear Plant Unit 1, Revision to Proposed Alternative to the American Society of Mechanical Engineers Code, Section XI Repair Requirements," AEP:NRC:5055-04, dated April 22, 2005.

This letter contains no new commitments. Should you have any questions, please contact Mr. John A. Zwolinski, Safety Assurance Director, at (269) 466-2428.

Sincerely,

Daniel P. Fadel
Engineering Vice President

RV/rdw

c: J. L. Caldwell, NRC Region III
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AFFIRMATION

I, Daniel P. Fadel, being duly sworn, state that I am Engineering Vice President of Indiana Michigan Power Company (I&M), that I am authorized to sign and file this request with the Nuclear Regulatory Commission on behalf of I&M, and that the statements made and the matters set forth herein pertaining to I&M are true and correct to the best of my knowledge, information, and belief.

Indiana Michigan Power Company

Daniel P. Fadel
Engineering Vice President

SWORN TO AND SUBSCRIBED BEFORE ME

THIS 24th DAY OF June, 2005

Notary Public

My Commission Expires 6/10/2007