September 25, 2006

Mr. Mano K. Nazar
Senior Vice President and
Chief Nuclear Officer
Indiana Michigan Power Company
Nuclear Generation Group
One Cook Place
Bridgman, MI 49106

SUBJECT: DONALD C. COOK NUCLEAR PLANT, UNIT 1 (DCCNP-1) - PRESSURIZER SAFETY NOZZLE STAINLESS STEEL SAFE END WELD CIRCUMFERENTIAL FLAW EVALUATION (TAC NO. MC7287)

Dear Mr. Nazar:

By letters dated June 3, 2005, and April 25, 2006, Indiana Michigan Power Company (I&M) submitted an evaluation of an indication that was detected in stainless steel weld 1-RC-9-01F at one of the three pressurizer safety valve nozzles during Cycle 20 Refueling Outage at DCCNP-1. The flaw evaluation was submitted because the indication in weld 1-RC-9-01F exceeded the acceptance criteria in Table IWB-3514-2 of the 1989 Edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI. I&M evaluated the indication in accordance with Subarticle IWB-3640 of the 1989 Edition of the ASME Code, Section XI.

The staff evaluated I&M's submittals and has delineated details of its review in the enclosed document. While the Nuclear Regulatory Commission (NRC) staff disagrees with the characterization and size of the initial flaw assumed in I&M’s flaw evaluation, the staff concludes that the structural integrity of weld 1-RC-9-01F is acceptable because I&M repaired weld 1-RC-9-01F with a full structural weld overlay, which was designed and inspected in accordance with the NRC staff’s approved Relief Request ISIR-17 (ADAMS Accession ML060240355). This completes the NRC's efforts on I&M's submittals.

Sincerely,

/RA/

Peter S. Tam, Senior Project Manager
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-315

Enclosure: As stated

cc w/encls: See next page

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SUMMARY OF FLAW EVALUATION BY

THE OFFICE OF NUCLEAR REACTOR REGULATION

INDIANA MICHIGAN POWER PRESSURIZER SAFETY NOZZLE SAFE END

DONALD C. COOK NUCLEAR PLANT, UNIT 1 (DCCNP-1)

DOCKET NO. 50-315

1.0 INTRODUCTION

By letters dated June 3, 2005 (Accession No. ML051650266), and April 25, 2006 (Accession No. ML061240077), Indiana Michigan Power Company (the licensee) submitted an evaluation of an indication that was detected in stainless steel weld 1-RC-9-01F at one of the three pressurizer safety valve nozzles during the Cycle 20 Refueling Outage at DCCNP-1. The indication in weld 1-RC-9-01F exceeded the acceptance criteria in Table IWB-3514-2 of the 1989 Edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI. Following the ASME requirement for indications exceeding the acceptance criteria, the licensee performed flaw evaluation to demonstrate the acceptability of leaving the indication in service in accordance with Subarticle IWB-3640 of the 1989 Edition of the ASME Code, Section XI.

On November 25, 2005, the Nuclear Regulatory Commission (NRC) staff transmitted to the licensee a request for additional information (Accession No. ML053290310) on the licensee's flaw evaluation and examination of the weld. The licensee responded by its April 25, 2006, letter.

The licensee repaired weld 1-RC-9-01F with a full structural weld overlay during the Cycle 20 Refueling Outage. By letter dated February 10, 2006, the NRC staff approved the licensee's Relief Request ISIR-17 for the weld overlay repair of weld 1-RC-9-01F (ADAMS Accession No. ML060240355).

2.0 REGULATORY REQUIREMENTS

Title 10 of the *Code of Federal Regulations,* Part 50, Section 55a (10 CFR 50.55a) requires nondestructive examinations of components in nuclear power plants be performed in accordance with the ASME Code, Section XI. The code of record for the third inspection interval at DCCNP-1 is the 1989 Edition of the ASME Code, Section XI. Subarticle IWB-3514.3 of the 1989 Edition of the ASME Code, Section XI, provides acceptance criteria (i.e., Table IWB-3514-2) for flaws detected in austenitic piping such as weld 1-RC-9-01F. Subarticle IWB-3640 of the ASME Code states that piping containing a flaw that exceeds the allowable flaw standards of IWB-3514.3, may be evaluated to determine its acceptability for continued service in accordance with IWB-3641 or IWB-3642. Subarticle IWB-3640 states further that the flaw evaluation shall be subject to approval of the regulatory authority having jurisdiction at the plant site.

3.0 TECHNICAL EVALUATION

The NRC staff reviewed the licensee's flaw evaluation and the technique, history, and results of the nondestructive examination of weld 1-RC-9-01F because the examination results provide information on the initial flaw size, which is an input to the licensee's flaw evaluation.

3.1 Review of Examination Results

During the Cycle 20 refueling outage, the licensee performed ultrasonic examinations of the Alloy 82/182 welds in the pressurizer nozzles. The licensee found an indication in weld 1-PRZ-23 which connects a pressurizer safety valve nozzle to the safe end. Subsequently, the licensee repaired weld 1-PRZ-23 by a full structural weld overlay. Weld 1-RC-9-01F is located adjacent to weld 1-PRZ-23 and also received a full structural weld overlay. As part of the weld overlay procedure, the licensee also performed ultrasonic examinations of both repaired welds. The licensee found the repaired weld 1-PRZ-23 to be acceptable. However, a circumferential indication was detected in weld 1-RC-9-01F, which connects the safe end to a pipe elbow. Both safe end and pipe are fabricated with stainless steel, SA-182, Grade F316.

The NRC staff asked the licensee whether the ultrasonic test (UT) method used in examining weld 1-RC-9-01F was qualified in accordance with Appendix VIII to ASME Code Section XI. In the April 25, 2006, letter, the licensee responded that the UT examination was qualified for: (1) detecting and sizing the length of fabrication flaws located in the weld overlay material or at the base material-overlay material interface; and (2) detecting and characterizing of circumferentially-oriented base metal flaws (length and depth) and axially oriented base metal flaws (depth only).

The NRC staff requested additional information regarding the sizing capability and accuracy of UT examination of base metal flaws that are repaired with a weld overlay. According to Supplement 11 of Appendix VIII to the ASME Code, Section XI, the UT examinations are qualified only for the outer 25 percent wall thickness of the base metal which is repaired with a weld overlay. In the June 3, 2005, letter, the licensee reported the thickness of weld 1-RC-9-01F as 0.646 inches. In Attachment 4 of the April 25, 2006, letter, the licensee reported weld thicknesses of 0.717 inches and 0.75 inches. In both letters, the licensee reported that the innermost edge of the indication (which is presumed to be an embedded flaw) is 0.09 inches from the inside surface of the pipe. Based on the above information, the indication is located in a region of the weld metal where UT is not qualified to detect or size flaws. Therefore, the size and depth of the indication, as reported by the licensee, along with the initial flaw size assumed in the licensee's flaw evaluation, are questionable.

To support the weld overlay repair for welds 1-PRZ-23 and 1-RC-9-01F, the licensee performed a finite element analysis of the structural weld overlay as shown in Westinghouse Report, "D.C. Cook Unit 1, Pressurizer Safety Valve Nozzle Safe-End Weld Overlay Repair," WCAP-16428-NP, May 2005 (attached to the licensee's April 25, 2006, letter). The NRC staff notes that WCAP-16428-NP is primarily an analysis for weld 1-PRZ-23, not for weld 1-RC-9-01F. However, the finite element model in the WCAP report included the configurations of both welds, the safety valve nozzle, the safe end and a portion of the pipe. The resulting residual stress distribution in weld 1-RC-9-01F was shown by the licensee to be compressive. The centerline of the detected indication is located at 36 percent of the wall thickness from the inside surface and, therefore, is within the compressive stress field. The compressive stress field is desirable because it will restrict the growth of the crack in weld 1-RC-9-01F. In addition, the licensee stated that there are no significant thermal transients occurring at the weld. Therefore, the presumed flaw is not expected to propagate further through the stainless steel weld.

The licensee stated that the root cause of the flaw in weld 1-RC-9-01F is associated with the compressive stress that was induced upon an original construction flaw, the cause of which may be slag, porosity, or lack of fusion. The indication was observed at or near the downstream fusion line. Weld 1-RC-9-01F received a pre-service examination in 1977 with 45- and 60-degree shear wave transducers and an insignificant indication was detected. At the time, the location or extent of the indication were not clearly identified. In 1997, the licensee performed a UT examination of the weld but did not identify any recordable indications at the location. As a result of the recent examination, the licensee reviewed the construction radiographic examination records of the weld and found a density change in the area of the indication, which would not have been the cause for rejection during construction. The licensee stated that the discrepancy between the 1977 and 1997 examination results is not unusual because of the changes in UT techniques, recording criteria, and personnel. The NRC staff agrees with the licensee that the UT examinations between 1977 and 1997, or between 1997 and 2006, are not the same because of the changes in technology. The licensee stated that, for the recent examination, UT personnel were also not able to determine whether the indication extends to the inside surface of the pipe regardless of UT transducer manipulation, even though the transducer was focused for the inside surface depth.

The licensee stated that, although the indication presented flaw-like signals, the response can be comparable to those produced by artificially manufactured flaws in the Electric Power Research Institute (EPRI) Performance Demonstration Initiative qualification blocks. EPRI uses a Cold-Isostatic Processing (CIP) technique, which uses high pressure to compress electro-discharge machining notches, thereby reducing the volume and sharpening the notch tips. The licensee stated that studies show that the notches create UT and eddy current test responses that are closely representative of primary water stress corrosion cracking. EPRI believes the compressive stresses induced during the weld overlay process are similar to the stresses induced by the CIP technique. The presence of a void (similar to slag, porosity, or lack of fusion) would similarly be compressed with a resulting reduction in volume and likely create notch tip signals.

3.2 Flaw Evaluation

The licensee's flaw evaluation involves using the initial flaw size obtained from the UT examination data, predicting the growth of the subject flaw, and comparing the final flaw size (initial flaw size plus flaw growth) to the ASME allowable flaw size to determine its acceptability. The goal is to demonstrate that the structural integrity of weld 1-RC-9-01F is acceptable, considering the existence of the flaw in the weld.

Based on the UT examination, the licensee assumed the initial crack depth of weld 1-RC-9-01F was 0.145 inches and the length was 0.30 inches. The indication was reported to be an embedded, nearly circular, sub-surface flaw oriented parallel to the radial and axial directions.

The diameter of the flaw is reported to be approximate 0.30 inches, and the inner edge of the flaw is reported to be 0.09 inches from the inner diameter of the pipe wall.

The licensee determined that the maximum allowable crack depth assuming a 360-degree circumferential flaw is 75 percent of the wall thickness based on the flaw evaluation procedures of Appendix C to the 1989 Edition of the ASME Code, Section XI. The wall thickness of the pipe of interest was reported to be 0.646 inches. Therefore, the allowable depth of the embedded flaw would be 0.484 inches (0.646 inches x 75 percent).

The licensee performed a crack growth calculation for the indication in weld 1-RC-9-01F based on Appendix C of the 1989 Edition of the ASME Code, Section XI. The crack growth mechanism for the indication in weld 1-RC-9-01F is attributed to fatigue. To determine the extent of fatigue crack growth in the stainless steel weld region, the applied loads consist of the piping reaction loads, pressure and thermal transient loads. One of the input parameters required for a fatigue crack growth analysis is delta K (range of stress intensity factors), which is a function of the geometry of the crack, its surrounding material and the range of applied stresses in the crack area. The licensee calculated delta K using the procedures of Appendix A of the 1989 Edition of the ASME Code, Section XI.

Another input parameter to the crack growth calculation is the design transient cycles. The licensee stated that the number of design transient cycles for a plant life of 40 years is the same as that for 60 years at D.C. Cook Unit 1. In the April 25, 2006, letter, the licensee provided the number of design transients, the number of actual transients as of 1998, and projected number of transients at the end of 60 years. The licensee's data show that the projected number of transients at the end of 60 years is within the number of the design transients. In addition, the licensee provided information on the number of transients for 60 years to support NRC's approval of the license renewal application for D.C. Cook. The NRC staff finds that the number of design transients is acceptable for use in the flaw growth calculation for the 60 years of plant operation.

The licensee's crack growth calculation showed that crack growth is negligible at the end of 60 years. The thickness of the weld overlay was not considered in the crack growth calculation, which is a conservative assumption. Had the weld overlay been included in the flaw growth calculation, the crack growth would have been less because the weld overlay imparts compressive stresses to impede crack growth. The NRC staff reviewed the licensee's information regarding the loading conditions and number of transient cycles. The NRC staff confirmed that flaw growth by fatigue in stainless steel weld 1-RC-9-01F is indeed negligible in accordance with crack growth curves of Appendix C of the 1989 Edition of the ASME Code, Section XI.

Since the licensee calculated negligible crack growth, the final crack depth does not exceed 75 percent of the pipe wall thickness (i.e., 0.484 inches). The final crack length was calculated by the licensee to be 0.30 inches. As stated above, the allowable crack length is assumed to be 360 degrees in the circumferential extent. Therefore, the final crack length of 0.30 inches is within the allowable crack length.

As discussed in Section 3.1 above, the NRC staff questioned the validity of the licensee's UT method to detect and size the flaw in the inner region (near the inside surface) of the pipe. The NRC staff does not agree with the initial flaw size used in the licensee's flaw evaluation because of the limits of the UT qualification. However, the issue of flaw size used in the licensee's evaluation is moot because the licensee applied a full structural weld overlay on weld 1-RC-9-01F. The full structural weld overlay is designed to provide reasonable assurance that structural integrity of the weld will be maintained as discussed in the NRC staff's approved Relief Request ISIR-17. Therefore, the NRC staff concludes that the full structural weld overlay, as designed and inspected in accordance with the NRC staff's approved Relief Request ISIR-17, will ensure adequate integrity of weld 1-RC-9-01F throughout the remaining licensed life of the plant.

4.0 CONCLUSION

The staff disagrees with the characterization and size of the initial flaw assumed in the licensee's flaw evaluation. Notwithstanding, the NRC staff concludes that the structural integrity of weld 1-RC-9-01F is acceptable because the licensee repaired weld 1-RC-9-01F with a full structural weld overlay, which was designed and inspected in accordance with the NRC staff's approved Relief Request ISIR-17.

Principal Contributor: John Tsao

Date: September 25, 2006

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