UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 27, 2014

Mr. Lawrence J. Weber
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, UNITS 1 AND 2 – REPORT FOR THE ONSITE AUDIT OF MOHR REGARDING IMPLEMENTATION OF RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDER EA-12-051 (TAC NOS. MF0761 AND MF0762)

Dear Mr. Weber:

On March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-12-051, "Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12054A679), to all power reactor licensees and holders of construction permits in active or deferred status. The order requires, in part, that all operating reactor sites have a reliable means of remotely monitoring wide-range Spent Fuel Pool (SFP) levels to support effective prioritization of event mitigation and recovery actions in the event of a beyond-design-basis external event (BDBEE). The order required all holders of operating licenses issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," to submit to the NRC an Overall Integrated Plan (OIP) by February 28, 2013.

By letter dated February 27, 2013 (ADAMS Accession No. ML13071A323), as supplemented by letters dated July 11, 2013 (ADAMS Accession No. ML13196A250), August 26, 2013 (ADAMS Accession No. ML13247A050), and February 27, 2014 (ADAMS Accession No. ML14063A041), Indiana Michigan Power Company (the licensee) submitted its OIP for Donald C. Cook Nuclear Power Plant, Units 1 and 2 (D.C. Cook).

The NRC staff's review led to the issuance of the D.C. Cook interim staff evaluation (ISE) and request for additional information (RAI) dated November 13, 2013 (ADAMS Accession No. ML13310B499). By letter dated February 27, 2014 (ADAMS Accession No. ML14063A041), the license answered most of the RAIs. By eportal document dated March 27, 2014, Indiana Michigan Power Company answered the remainder of the RAIs.

As part of the D.C. Cook OIP, the licensee identified MOHR as their provider for the SFP instrumentation. By letter dated April 28, 2014 (ADAMS Accession No. ML14115A315), the NRC issued an audit plan for an onsite audit, at the MOHR facility, of the SFP instrumentation. During the week of May 26, 2014, the NRC staff audited MOHR's SFP instrumentation design.

The enclosed audit report provides a summary of the NRC staff activities and the documents reviewed related to MOHR's SFP instrumentation design as it applies to D.C. Cook and other licensees using the MOHR technology to comply with the requirements of Order EA-12-051.

Sincerely,

John P. Boska

John Boska, Senior Project Manager
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos.: 50-315 and 50-316

Enclosure:
Audit Report

cc w/encl: Distribution via Listserv

AUDIT REPORT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO ORDER EA-12-051 MODIFYING LICENSES

WITH REGARD TO REQUIREMENTS FOR

RELIABLE SPENT FUEL POOL INSTRUMENTATION

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK NUCLEAR POWER PLANT, UNITS 1 AND 2

DOCKET NOS. 50-315 and 50-316

BACKGROUND

On March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-12-051, "Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12054A679), to all power reactor licensees and holders of construction permits in active or deferred status. The order requires, in part, that all operating reactor sites have a reliable means of remotely monitoring wide-range Spent Fuel Pool (SFP) levels to support effective prioritization of event mitigation and recovery actions in the event of a beyond-design-basis external event (BDBEE). The order required all holders of operating licenses issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," to submit to the NRC an Overall Integrated Plan (OIP) by February 28, 2013.

By letter dated February 27, 2013 (ADAMS Accession No. ML13071A323), as supplemented by letters dated July 11, 2013 (ADAMS Accession No. ML13196A250), August 26, 2013 (ADAMS Accession No. ML13247A050), and February 27, 2014 (ADAMS Accession No. ML14063A041), Indiana Michigan Power Company (the licensee) submitted its OIP for Donald C. Cook Nuclear Power Plant, Units 1 and 2 (D.C. Cook).

The NRC staff's review led to the issuance of the D.C. Cook interim staff evaluation (ISE) and request for additional information (RAI) dated November 13, 2013 (ADAMS Accession No. ML13310B499). By letter dated February 27, 2014 (ADAMS Accession No. ML14063A041), the license answered most of the RAIs. By eportal document dated March 27, 2014, Indiana Michigan Power Company answered the remainder of the RAIs.

As part of the D.C. Cook OIP, the licensee identified MOHR as their provider for the SFP instrumentation. By letter dated April 28, 2014 (ADAMS Accession No. ML14115A315), the NRC issued an audit plan for an onsite audit, at the MOHR facility, of the SFP instrumentation. During the week of May 26, 2014, the NRC staff audited MOHR's SFP instrumentation design verification analyses and performance test results in support of the NRC staff review of D.C. Cook's OIP in response to the Reliable SFP Instrumentation order (Order EA-12-051).

Enclosure

AUDIT ACTIVITIES

The onsite audit was conducted at the MOHR facility, Richland, WA from Wednesday, May 28, 2014 through Thursday, May 29, 2014. The NRC audit team staff present was as follows:

Carla P. Roque-Cruz	NRR/JLD
Rossnyev Alvarado	NRR/DE
Steven Wyman	NRR/DE
Gursharan Singh	NRR/JLD
Khoi Nguyen	NRR/JLD

During the audit, the NRC staff performed a review of the Spent Fuel Pool Instrumentation (SFPI) technical and design information, as available. Activities that were performed in support of the above included detailed analysis and calculation discussions, equipment demonstration, and discussions with the vendor staff on specific topics.

MOHR's Electric Field Perturbation (EFP)-IL SFPI system for D.C. Cook consist of the EFP-IL Signal Processor, EFP-BAT Battery Enclosure, and SFP-1 Level Probe Assembly.

AUDIT SUMMARY

1. Temperature, Humidity and Radiation (Environmental Conditions) Qualification – ISE RAI#6 and RAI#7

SFPI system electronics

MOHR's SFPI system electronics is designed for installation in a normally mild environment remote from the SFP area. The SFPI system electronics and batteries are housed in NEMA Type 4X metallic enclosures designed for installation in this type of environment.

MOHR Document No. 1-0410-1, "MOHR EFP-IL SFPI System Temperature and Humidity Test Report," Revision 1, describes the test and test results of temperature and humidity tests performed on the SFPI electronics. Using licensee-provided and site-specific input, temperature and humidity tests were performed in accordance with MIL-PRF-28800F, "General Specification for Test Equipment for Use with Electrical and Electronic Equipment."

MIL-PRF-28800F defines specific conditions for environmental testing. However, these conditions did not envelope most site-specific environments for the location of the SFPI electronics. MOHR addressed this issue by revising the temperature and humidity test levels in a manner appropriate to envelope the temperature and humidity in a normally mild environment at the site. As a result, MOHR performed environmental testing at the following worst-case post-event environmental conditions of temperature -10 to +55 °C (14 to 131 °F) and 5 to 95 percent Relative Humidity (RH).

Before performing temperature and humidity tests, MOHR tested operability of the equipment under standard ambient conditions, which are defined in MIL-PRF-28800F as 25 ± 10 °C and 20 to 70 percent RH. This test established the level of performance characteristics of the system. MOHR also performed pre-qualification testing at 20 °C and 36 percent RH, adjusting the level

for the probe to simulate 0 percent, 50 percent and 100 percent immersion. The results obtained during pre-qualification were used as the acceptance criteria for temperature and humidity testing.

During the temperature test, which consisted of five separate sections designed to cover the specified temperature range, MOHR placed the equipment inside an environmental chamber and temperature was varied in accordance with the conditions defined in the test procedure. Conditions in each test section were maintained for one hour, after which operating tests were performed. Results of the operating test were compared to the results obtained during pre-qualification testing and the result showed the equipment operation was acceptable under the test conditions required.

Based on site-specific parameters, the licensee requires the SFPI system electronics to operate in temperature conditions of 60-104 ºF. Based on the temperature tests results, the equipment is qualified to operate in the temperature conditions identified by the licensee.

The humidity test also consisted of five separate sections designed to cover both the humidity and temperature range defined in test procedures. The conditions for each test section were as follows:

- Section 1: ambient conditions (Temperature: 25 ± 10 °C (77 ± 18 °F), and Humidity: 20 to 70 percent RH)
- Section 2: Temperature of 55 °C (131 °F) and relative humidity of 40-50 percent
- Section 3: Temperature of 40-50 °C (104-122 °F) and relative humidity of 70-80 percent
- Section 4: Temperature of 30 °C (86 °F) and relative humidity of 95 percent

The equipment was placed inside an environmental chamber. Conditions in each section were maintained for one hour, after which operating tests were performed. The test results showed the equipment operation was acceptable under the test conditions required. At the completion of the temperature and humidity tests, MOHR performed a post-test inspection to determine if degradation of the system could be observed. This test inspection was performed at 28 °C (82 °F) and 35 percent RH. MOHR found the post-qualification test results were satisfactory.

The licensee specified that the SFPI system should operate in conditions of 60-104 ºF and 80 percent RH. Based on the humidity and temperature tests performed, the SFPI has been qualified to operate at a maximum temperature of 47 ºC (116.6 ºF) and 71 percent RH, which is lower than the RH specified by the licensee. As a result, if the equipment is installed in areas with humidity above the qualified values, the licensee should verify that the equipment can operate under that temperature and elevated RH condition.

The licensee provided the vendor with Calculation RD-13-03, "Radiation Dose to Spent Fuel Pool Level Instrumentation in Accordance with the Nuclear Energy Institute (NEI) guidance document NEI 12-02, Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation" (ADAMS Accession No. ML 12240A307), which summarizes the radiation dose expected after a 7-day post-event (1.053E+08 rad) and 40-year normal operational radiation doses (7.814E+06 rad as the worst case dose rate for the specification of the probe head and 6.5E+08 rad for the probe body) at the elevations for Levels 1, 2 and 3 in the DC Cook SFP, as defined in NEI 12-02.

For the SFPI systems electronics, MOHR did not perform radiation testing because the expectation is that the licensee will install the system electronics in the control room, which is a mild environment. If a licensee, using MOHR technology, decides to install the system electronics outside the main control room, radiation testing should be performed to demonstrate the reliability of the equipment under radiation conditions expected in the area of installation. Additionally, MOHR did not consider non-seismic or post-event aging mechanisms for the SFPI system electronics, because the electronics would be installed in a normally mild environment and the specified post-event temperature and humidity level is considered within normal operating range for commercial electronic components under an anticipated exposure of short duration.

Coaxial Transmission Cable

MOHR uses Class 1E Nuclear Safety Related RSCC Wire & Cable RSS-6-110A/LE which meets the requirements of Institute of Electrical and Electronic Engineers (IEEE) 383-1974, "IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations." During the audit, MOHR provided to the NRC staff a copy of the "Qualification Report – QR6802 on Qualification Tests for Firewall Adverse Service Coaxial, Twinaxial, and Triaxial Cable Construction for Class 1E Service in Nuclear Generating Stations", performed by the cable supplier. This report summarizes the testing performed to demonstrate that the coaxial cable would function during a Loss of Coolant Accident (LOCA)/Design Basis Event (DBE) postulated to occur during the 40 years of operation under conditions as prescribed by IEEE 383-1974. The results of this report are also discussed in MOHR Document No. 1-0410-2, "MOHR SFP-1 Level Probe Assembly Materials Qualification Report." In this document, MOHR noted that they do not expect the cable to be subject to aqueous exposure during routine pool operations, and brief exposure may occur as a result of pool sloshing during a seismic event.

Level Probe Assembly

The SFP- 1 level probe assembly consists of a metallic waveguide, a repairable head, and a hardline cable connector. The repairable head is a coaxial adapter that connects the transmission cable to the body of the SFP-1 probe. The body of the SFP-1 probe assembly will be submerged in the SFP, and will be subjected to the associated temperature, corrosion and radiation conditions for a 40-year design life. The repairable head will be located above the maximum SFP water level, and is therefore subject to a substantially milder environment than the probe body.

MOHR Document No. 1-0410-2, "MOHR SFP-1 Level Probe Assembly Materials Qualification Report," describes the properties of the materials of construction and documents the suitability of the SFP-1 probe assembly for operation in the SFP environment. The SFP-1 probe assembly is constructed primarily of stainless steel (SS). The dielectric polyether-ether-ketone (PEEK) spacers in the probe body provide temperature, boric acid, and radiation resistance suitable for prolonged exposure to the SFP aqueous environment. MOHR uses ethylene propylene diene terpolymer (EPDM) seals (O-ring and gasket) at the upper part of the repairable head.

Qualification of the SFP-1 probe entails demonstrating the elastomers, metals and alloys used are resistant to degradation by the thermal, corrosion, and radiation conditions of the SFP environment. In particular, the probe must be able to tolerate SFP conditions for 40 years subject to water temperatures higher than 40 °C (104 °F) and boric acid concentrations up to about 4,000 parts per million by weight of boron (wppm B). During abnormal conditions, temperature may increase to 100 °C (212 °F) and 100 percent RH with postulated boric acid concentrations of about 9,000 wppm B for up to 7 days. Cumulative radiation dose up to 2 gigarad (Grad) (20 megagray (MGy)) for EPDM or 10 Grad (100 MGy) for PEEK is assumed for the lowermost spacer located nominally 3 to 4 feet (0.9 to 1.2 meters) above the fuel rack.

For testing, the variables considered were: temperature, corrosion (boric acid and other SFP constituents), and radiation. MOHR Document No. 1-0410-2 describes the analysis and studies performed. Based on test results, MOHR concluded that the SFP-1 probe metallic waveguide, EPDM and dielectric spacers' construction materials would not be challenged by the thermal, corrosion, and radiation characteristics of the SFP aqueous environment.

The repairable head is constructed of material also resistant to temperature, corrosion, and radiation. MOHR noted that occasional trace transient exposure to SFP water might result from normal pool operation and complete immersion during postulated accident conditions. However, no prolonged SFP water exposure is expected and long-term corrosion effects are therefore not considered for this component. Additionally, the repairable head could be quickly replaced in case of damage. MOHR document No. 1-0410-2 states that the service life for the SFP-1 repairable head in the SFP environment is bounded by the conditions of the probe design. Furthermore, Section 4 of this report describes materials qualifications to support 40-year service life. The hardline cable and its connector materials were also evaluated in this report. MOHR states that the hardline cable would be chemically and radiation resistant to the levels exposed in the SFP area and the vendor does not expect the hardline cable connector to have contact with water during normal pool operation. In addition, MOHR considers this component would not be challenged by an occasional aqueous exposure that may occur as a result of pool sloshing during postulated accident conditions, nor be challenged by the expected thermal or radiation environment. Based on the tests and analysis for these materials, MOHR concluded the MOHR SFP-1 level probe assembly is suitable for 40-year service life in the SFP environment.

Boric Acid Deposition

MOHR Document No. 1-0410-8, "MOHR EFP-IL SFPI System Boric Acid Deposition Report," describes boric acid testing and analysis used by MOHR to demonstrate operation of its SFPI in the presence of boric acid in the SFP aqueous coolant and in the form of boric acid salts deposited on equipment installed in the SFP.

For this evaluation, MOHR considered that boric acid and boric acid salts would form deposits on equipment surfaces in contact with the aqueous coolant, which might affect level measurement. The rate of buildup and dissolution may vary depending on boric acid concentration in the SFP aqueous solution. Boric acid deposition was tested by cyclically immersing sample SS into a solution of boric acid until boric acid built up on the material, simulating typical evaporative loss and refilling cycles encountered in a typical SFP. The cycle

was continuously repeated for several weeks. In addition, MOHR performed tests to determine the difficulty of removing the deposited boric acid with deionized water.

MOHR also tested the relationship between temperature and boric acid dissolution rate and the effect of prolonged immersion in boric acid solution. MOHR found the rate of boric acid deposition increased with increasing immersion cycle number or prolonged exposure to the boric acid solution. Also, MOHR observed larger buildup of boric acid towards the top and on the side edges of the samples. For the prolonged immersion of boric acid solution, MOHR immersed the test sample in saturated boric acid solution at room temperature for 28 days. After this period, MOHR did not observe physical changes or visible deposition on the samples or any physical changes or visible deposition in the PEEK and EPDM.

After completing the boric acid build up, MOHR tested the effect of boric acid solution at varying concentrations and boric acid sludge with varying water content in the dielectric constant to determine if it will have any effect on the level measurement. MOHR found the worst-case level measurement error to be approximately 2.5 inches (in.) in the presence of hydrated boric acid precipitate. MOHR recommends a threshold for mitigation efforts at ≥ 3 in. of measurement error.

Based on the results, MOHR concluded that the presence of borated water or boric acid deposits will not significantly affect the ability of the SFPI system to measure water level in the SFP. However, the presence of boric acid precipitate on the SFP-1 probe's active electrode surfaces above the water level produces a fixed minor measurement error. MOHR recommends routine washing of the probe to remove boric acid build up.

2. Seismic Qualification – ISE RAI #3 and RAI #4

Seismic test results for the SFPI signal processing unit and the extended battery are documented in MOHR's document No. 1-4010-6, "Seismic Test Report" Rev. 1, dated February 6, 2014. These tests were conducted on a triaxial shake table using the guidance of IEEE 344-2004, Sections 7, 8, 9, and 10 as recommended in the NRC's Japan Lessons-Learned Project Directorate (JLD) Interim Staff Guidance(ISG) document, JLD-ISG-2012-03 "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation" (ADAMS Accession No. ML12221A339).

Prior to performing the tests, a resonance test was conducted to check for any resonances in the low frequency range. MOHR indicated that the resonance search was conducted up to 33 hertz (Hz) as IEEE 344-2004 does not require resonance testing beyond 33 Hz. The vendor also stated that additional consideration for the resonance factors was not necessary because the test was performed using a shake table test and any resonance will automatically be included during the testing.

Full functional performance tests were also conducted prior to the seismic table test. A set of five operating basis earthquake (OBE) tests were conducted with the power on to ensure that the indication is continuous with no faults and no loss of functionality (i.e. loss of display). The data was recorded for analysis. In addition to the OBE tests a safe shutdown earthquake (SSE) test was also conducted. Fragility tests were conducted to a peak of 9.8g for OBE and a peak

of 14g for SSE per the test criteria since this was a generic qualification test which is intended to cover all sites that use the MOHR SFPI technology.

Post-test functional tests were conducted with satisfactory results. The vendor noted that the equipment performed well after the tests, as it did in pre-functional tests, with no deficiency or anomalies found during testing. The battery voltage variation was also acceptable.

NRC's audit staff also reviewed MOHR's document No. 1-0410-9.1, "SFP-1 Site-Specific Seismic Analysis Report: Donald C. Cook Nuclear Plant (D.C. Cook)," Rev.1, dated May 1, 2014. This seismic test report is specific to the D.C. Cook site for the signal processing unit and the extended battery enclosure. The results of the analysis show that the calculated stresses are well within the allowable stresses. This site specific analysis states that the D.C. Cook probe is 10 in. from both the SFP walls in the selected corners of the SFP and will not impact the pool liner during the postulated seismic event and resulting sloshing.

MOHR's document No. 1-0410-9, "SFP-1 Level Probe Assembly Seismic Analysis Report," Rev. 2, dated May 12, 2014 addresses the seismic adequacy of the SFP level probe assembly. This report is generic in nature and each licensee should verify that their site-specific analysis for their probe assembly is enveloped by this test's parameters. In this instance, the seismic test criteria used in the report is significantly higher than the seismic criteria for MOHR's pilot site, D.C Cook. Seismic loads and SFP water sloshing loads were included in this report. The sloshing analysis was based on GOTHIC, an industry-standard computer code for performing multiphase fluid flow. ANSYS, a finite element analysis computer code, was used to perform the hydrodynamic loading and structural analysis. A code-to-code verification was performed between ANSYS and GOTHIC with good results. A series of sensitivity analyses were conducted, which included pool length, boundary conditions, liquid height and loss of SFP inventory. The report indicates that the distance from the probe to the pool liner is 12 in. for the analyses performed. This distance may vary depending on site-specific installation. The analysis concluded that the maximum stresses on the probe are lower than the maximum allowable stresses.

Calculations performed during testing showed that the probe has a high likelihood of impacting the SFP metal liner several times during a seismic event. To verify the probe functionality under such conditions, MOHR performed physical impact tests and test results confirmed that mechanical integrity of the probe and the SFP liner were preserved. The pictures after the tests showed little to no damage to the liner or the probe.

Analysis was also performed to derive shear forces, axial loading, and bending moments at the mounting flange location due to seismic and hydrodynamic loading of the probe. Test results are documented in Table-1 of MOHR's document No. 1-0410-9 and include flange forces, bending moments, peak displacement, and peak probe velocity in all three directions (x, y, and z directions). All the stress forces are within the allowable limits. Based on the test results from this generic analysis, MOHR found the SFPI level probe assembly acceptable for use.

3. Shock and Vibration – ISE RAI#6

The NRC staff reviewed MOHR document No. 1-0410-5, "MOHR EFP-IL SFPI System Shock and Vibration Test Report," Rev. 0, dated October 19, 2013, and No. 1-0410-9, "MOHR SFP-1 Level Probe Assembly Seismic Analysis Report," Rev. 2, dated May 12, 2014, for the SFPI shock and vibration qualification. The non-seismic mechanical shock and vibration tests for the SFPI equipment were performed by Cascade Technical Sciences, Inc. According to Section 3.1, "Test Standards," of Document No. 1-0410-5, shock tests were performed in accordance with International Electrotechnical Commission (IEC) document IEC 60068-2-27 and vibration tests were performed in accordance with IEC 60068-2-6.

Section 2.0, "Equipment," of document No. 1-0410-5, states that the equipment tested for shock and vibration included the signal processor electronics (EFP-IL), the external battery enclosure (EFP-BAT-44000), and their associated cables. MOHR indicated that the results of the impact test performed on the probe will be credited for the shock test as well. These results were satisfactory showing that impacts of up to 17 feet per second did not cause any damage to the probe. Vibration testing was not performed for the probe assembly due to the size of the probe. Based on concerns raised by NRC staff regarding the lack of vibration testing for this component, this issue was identified as an open item to be addressed by the vendor.

In response to the open item, MOHR submitted document No. 1-0410-16, "MOHR SFP-1 Level Probe Assembly Shock and Vibration Test Report," dated July 8, 2014, describing additional testing performed to the probe assembly. According to this report, a shock test was performed in accordance with IEC 60068-2-27 and a vibration test was performed in accordance with IEC 60068-2-6. Functional verifications were performed prior to and after each testing phase to identify the deficiencies. Mechanical fastener functional verifications were also performed. The test results were satisfactory. The NRC staff finds that this testing is sufficient to close the open item.

4. Instrument Accuracy, Calibration and Testing – ISE RAI#10 and RAI#11.

MOHR document No. 1-0410-3, "MOHR EFP-IL SFPI Proof of Concept Report," Rev. 0, dated October 17, 2012 states, in part, that the effects of temperature and humidity are insignificant with regard to measurement accuracy. The instrument accuracy is approximately 0.04 to 0.5 in. The results from testing performed on the probe at 500 °F in saturated steam (100 percent RH) showed a system accuracy of approximately 0.5 in. MOHR Document No. 1-0410-15, "MOHR EFP-IL-SFPI System Uncertainty Analysis," states, in part, that the EFP-IL-SFPI system, configured with a maximum length of transmission cable of 1000 ft., stays within the level measurement accuracy of +/- 3 in. EFP-IL-SFPI system error is highest but still acceptable at the bottom of the probe near the top of the fuel rack.

MOHR Document No. 1-0410-10, "MOHR EFP-IL SFPI System Power Interruption Report," Rev. 1 dated January 10, 2014, describes power interruption testing on the EFP-IL signal processing unit and battery. Test results indicate that no deficits were identified with respect to maintenance of reliable function, accuracy, or calibration as a result of power interruption. The SFPI system's accuracy was maintained without recalibration following the power interruption. MOHR document No. 1-0410-12, "MOHR EFP-IL Signal Processor Operator's Manual," 1-0410-13, "MOHR EFP-IL Signal Processor Technical Manual," and 1-0410-14, "MOHR SFP-1 Level

Probe Assembly Technical Manual" provide the testing and calibration procedures for the SFPI. MOHR's SFPI design can be calibrated in-situ without removal from its installed location. The system is calibrated using a CT-100 device and processing of vendor scanned files. MOHR document No. 1-0410-13, Section 6.5, "Calibration," provides recommended calibration intervals to be followed by users of this technology. D.C. Cook staff present during the audit indicated that licensee staff is visiting the vendor site and training on maintenance, installation and operation of MOHR's SFPI technology.

Based on test results, MOHR concluded that the SFPI's accuracy is not adversely impacted by conditions of temperature and humidity and can be maintained without recalibration following a power interruption. The NRC staff found the instructions and recommendations for calibration of the SFPI to be thorough and user-friendly.

5. Power Consumption ISE IRA #9

The NRC staff reviewed MOHR document No. 1-0410-10, "MOHR EFP-IL SFPI System Power Interruption Report," Rev. 1, dated January 10, 2014. MOHR's SFPI channels received their normal power from a 120 volt alternating current (Vac) external supply. Internal system electronics are powered by regulated direct current (dc) power. Alternating current to direct current power conversion is performed by the 24 Vdc power module. A backup power source is provided by four redundant 14.4 Vdc battery packs, which are monitored and charged as needed. These battery packs are connected to the common dc power rail and in the absence of normal power sources, the highest voltage battery will supply the common dc rail. The backup-power batteries were tested for seismic, shock and vibration, and environmental qualification.

Power interruption testing was performed with the EFP-IL signal processor and EFP-BAT-44000 battery enclosure at MOHR facilities. No deficits were identified with respect to function reliability, accuracy, or calibration as a result of power interruption

According to Document No. 1-0410-7, "MOHR EFP-IL SFPI System Battery Life Report," Rev. 2, dated February 25, 2014, the backup-power battery packs were tested to full discharge at several discharge rates to determine the battery capacity. The test data shows that when the system instrument was configured to operate in minimum power mode with sample rate of 15 samples per hour at room temperature, the battery capacity had 82 percent remaining after 17.8 days of operation. The backup-power source can provide at least 7-day battery life with minimum power mode using an average sample rate of 15 samples per hour. Based on test results, MOHR determined that the SFPI's replaceable batteries used for instrument channel power have sufficient capacity to maintain the level indication function for longer than 7 days.

6. Electro-Magnetic Compatibility (EMC) Testing – Vendor Audit RAI

MOHR performed EMI testing to the standards of Electric Power Research Institute (EPRI) document EPRI TR-102323-R3, "Guidelines for Electromagnetic Interference Testing of Power Plant Equipment." The NRC staff confirmed the performance and test results during the review of MOHR document No. 10410-4, "Mohr EFP-IL SFPI System EMC Test Report," Rev. 2, dated March 13, 2014. The vendor did not perform any susceptibility testing, citing Table 1 of the EPRI TR for non-safety related equipment. MOHR also took an exemption for low frequency conducted and radiated emissions based on analyses provided in Sections 3.1.1 and 3.1.2 of

the EMC test report. However, MOHR did perform susceptibility testing on the CT100 product which is a commercially packaged version of the EFP-IL. The CT100 EMC report was made available to the NRC for audit in MOHR document No. 1-0410-4-S1, "Mohr EFP-IL SFPI System Supplemental EMC Information." The testing included immunity testing to IEC 61326 which is the IEC EMC standard for test and lab equipment. IEC 61326 uses the 61000 series test method, but has different criteria. The NRC staff confirmed the test results for the IEC 61000-6-4 high frequency conducted and radiated emissions test. Licensees should be aware that the low frequency emissions' testing was not conducted and test results do not specifically envelope the immunity performance of the EFP-IL.

MOHR indicates in Section 5.0 of MOHR document No. 10410-4 "Mohr EFP-IL SFPI System EMC Test Report" Rev. 2, that the EFP-IL meets the requirements for non-safety-related equipment in EPRI TR 102323 R3. No immunity was required to be performed, but commercial immunity testing for a related product was provided for reference. The NRC staff did not identify any issues with the results for the portions of the EMC testing performed.

As a result of the NRC staff's evaluation of the EMC testing results, the staff identified a generic open item applicable to all licensees using this technology to identify any additional measures, site-specific installation instructions or position taken to address the potential effect of an EMC event on the SFPI equipment.

Exit Meeting (Thursday, May 29, 2014)

The NRC staff audit team conducted an exit meeting with MOHR, Indiana Michigan Power and NEI staff following the completion of audit review activities. The NRC staff highlighted items reviewed and noted that a detailed summary of the audit activities will be documented in this audit report.

Conclusion

The NRC staff completed the MOHR SFPI audit in support of the staff's review of the D.C. Cook integrated plan in response to NRC Order EA-12-051. The review audit activities and results summarized in this report apply to D.C. Cook and other licensees using MOHR's level measurement technology as appropriate. The audit process will continue until the NRC staff issues a final safety evaluation to the licensees. If additional information is requested by the NRC staff, based on site-specific installations of the SFPI, the information can be provided to the staff via the licensees' e-portals, conference calls with the staff, letters, or site visits.

Based on this audit, the NRC staff gained understanding and verified the design and qualification process used by the vendor to confirm the reliability of the SFPI. The staff found the SFPI design and qualification process acceptable. The information and calculations provided by the vendor allowed the staff to identify licensee information that will require docketing to confirm that the installation of the instrumentation at the site is enveloped by the SFPI's design.

In support of the continuing audit process, as Indiana Michigan Power proceeds towards compliance with the orders for the D.C. Cook, the NRC audit report titled "Donald C. Cook Nuclear Plant, Units 1 and 2 - Report for the Audit Regarding Implementation of Mitigating

Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0766, MF0767, MF0761, and MF0762)" (ADAMS Accession No. ML14209A122) provides information on the remaining D.C. Cook open items related to the SFPI.

Documents Reviewed

1. MOHR Document No. 1-0410-1, "MOHR EFP-IL SFPI System Temperature and Humidity Test Report," Rev. 1

2. MOHR Document No.1-0410-1A, "MOHR EFP-IL SFPI System Temperature and Humidity Test Procedure"

3. MOHR Document No. 1-0410-2, "MOHR SFP-1 Level Probe Assembly Materials Qualification Report"

4. MOHR Document No. 1-0410-3. "MOHR EFP-IL SFPI System Proof of Concept Report," Rev. 0, dated October 17, 2012

5. MOHR Document No. 10410-4 "Mohr EFP-IL SFPI System EMC Test Report," Rev. 2, dated March 13, 2014

6. MOHR Document No. 1-0410-4-S1, "Mohr EFP-IL SFPI System Supplemental EMC Information"

7. MOHR Document No. 1-0410-5, "MOHR EFP-IL SFPI System Shock and Vibration Test Report," Rev. 0, dated October 19, 2013

8. MOHR Document No. 1-040-6, "EFP-IL SFPI System Seismic test report," Rev.1

9. MOHR Document No. 1-0410-7, "MOHR EFP-IL SFPI System Battery Life Report," Rev. 2, dated February 25, 2014

10. MOHR Document No. 1-0410-8, "MOHR EFP-IL SFPI System Boric Acid Deposition Report"

11. MOHR Document No. 1-0410-9, "Mohr SFP-1 Level Probe Assembly Seismic Analysis Report," Rev. 2, dated May 12, 2014

12. MOHR Document No. 1-0410-9.1 "Mohr SFP-1 Site-Specific Seismic Analysis Report: Donald C. Cook Nuclear Plant (D.C. Cook)," Rev.1, dated May 1, 2014

13. MOHR Document No. 1-0410-10, "MOHR EFP-IL SFPI System Power Interruption Report," Rev. 1, dated January 10, 2014

14. MOHR Document No. 1-0410-12, "MOHR EFP-IL Signal Processor Operator's Manual"

15. MOHR Document No. 1-0410-13, "MOHR EFP-IL Signal Processor Technical Manual"

16. MOHR Document No. 1-0410-14, "MOHR SFP-1 Level Probe Assembly Technical Manual"

17. MOHR Document No. 1-0410-15, “MOHR EFP-IL-SFPI System Uncertainty Analysis”

18. MOHR Document No. EVAL-194-4812-01, “Mohr EFP-IL Liquid Level Measurement System Failure Modes and Effects Analysis,” Rev. 1

19. MOHR Document No. 2014.01, “Factory Acceptance Test Liquid Level Sensing System,” Rev. 3

The enclosed audit report provides a summary of the NRC staff activities and the documents reviewed related to MOHR's SFP instrumentation design as it applies to D.C. Cook and other licensees using the MOHR technology to comply with the requirements of Order EA-12-051.

Sincerely,

/RA/

John Boska, Senior Project Manager
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos.: 50-315 and 50-316

Enclosure:
Audit Report

cc w/encl: Distribution via Listserv

DISTRIBUTION:
PUBLIC
JLD R/F
RidsNrrDorlLpl3-1 Resource
RidsNrrPMDCCook Resource
RidsRgn3MailCenter Resource
RidsAcrsAcnw_MailCTR Resource
RidsNrrLASLent Resource
JBoska, NRR/JLD/JOMB

ADAMS Accession No. ML14216A362

OFFICE	NRR/JLD/JERB	NRR/JLD/JOMB/PM	NRR/JLD/LA	NRR/JLD/JERB/BC
NAME	CRoque-Cruz	JBoska	SLent	BPham
DATE	08/18/14	08/18/14	08/05/14	08/19/14
OFFICE	NRR/JLD/JCBB/BC	NRR/JLD/JOMB/BC	NRR/JLD/JOMB/PM	
NAME	SBailey	JBowen (MHalter for)	JBoska	
DATE	08/26/14	08/19/14	08/27/14	

OFFICIAL AGENCY RECORD