UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

December 1, 2008

NRC INFORMATION NOTICE 2008-18: LOSS OF A SAFETY-RELATED MOTOR CONTROL CENTER CAUSED BY A BUS FAULT

ADDRESSEES

All holders of operating licenses for nuclear power reactors, except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel, as well as all holders of operating licenses or certificates of fuel cycle facilities.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of a recent event involving an electrical fire caused by a bus fault at the Arkansas Nuclear One Unit 2 (ANO 2) power plant, which resulted in the loss of a safety-related motor control center (MCC) and the associated loss of one division of some safety-related loads. The NRC expects recipients to review the information for applicability to their facilities and to consider actions, as appropriate, to avoid similar problems. The suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

An electrical fire caused by a bus fault occurred at ANO 2 on October 23, 2007, and resulted in the loss of a safety-related MCC and the associated loss of one division of some safety-related loads. On this occasion, centrifugal charging pump 'A' was undergoing routine surveillance testing following mechanical maintenance. While operators were starting the pump remotely from the control room, a fire occurred in MCC Cubicle 2B-52A5, which caused the loss of power to the MCC 2B-52 because its upstream load center breaker tripped. As a result, the licensee declared the associated safety-related Division 'A' loads inoperable, including the low-pressure and high-pressure safety injection pumps, the control room emergency chiller, and the containment spray pump. The licensee declared an Alert on ANO 2 because the onsite fire affected one power train of engineered safety feature systems. Operators realigned the electrical equipment in accordance with plant procedures, and the plant exited the Alert 1½ hours after it was declared.

The licensee's root-cause analysis indicated that the fire originated in MCC Cubicle 2B-52A5, which supplies centrifugal charging pump 'A'. This cubicle had a large starter, which was located at the bottom of the MCC in the A column. The licensee found that all three vertical aluminum bus bars in A column had melted (from bottom up) to the first horizontal bus brace. Videoscope photographs behind the bus work showed molten metal slag at the outer C and B phases where the 2B-52A5 stab fingers engage the bus bars. Although the stab fingers were aligned with the bus bars, the visual inspection following the removal of the starter cubicle and bus safety barrier indicated that the engagement and contact of the stab fingers on all the three

phase bus bars were questionable. MCC Breaker 2B-52A5 did not trip during the event because the fault was on the source side of the breaker (bus bars) at the MCC. The fault event at the MCC occurred in the following sequence:

(1) Service-related conditions (i.e., large loads, frequent starts, repetitive starts, equipment age, and environmental conditions) caused a high-resistance connection to develop at the MCC bus/stab interface, leading to arcing at MCC Cubicle 2B-52A5.

(2) The arcing at the connection caused a phase-to-ground fault at the stab/bus connection, which moved to the bottom of the MCC. As this fault progressed to a phase-to-phase fault, it vaporized the bottom of each bus bar.

(3) The heat from the fault caused the MCC plastic base pan and space heater wires in the MCC to catch on fire.

(4) The pressure from the fault caused the side wireway door to open.

(5) The upstream 480-volt feeder breaker then tripped open and interrupted the fault. The fire in the base of the MCC extinguished itself, ending the event sequence.

The MCC bus bars consisted of tin-plated aluminum, whereas the cubicle bus stabs consisted of tin-plated copper alloy. Any loss of the tin plating could result in the oxidation of bare aluminum and the development of a high-resistance connection at the stab/bus bar interface. The fault and the resulting fire were primarily caused by the high-resistance connection at the stab/bus interface, combined with the high starting current associated with large load.

The licensee identified the following two factors as contributing to high resistance at the stab/bus bar interface:

(1) Preventive maintenance was inadequate. The existing procedures did not require lubrication, which conflicted with the industry practice and cubicle installation instructions contained in the MCC technical manual. Lubrication protects against aluminum oxidation and plate damage. The preventive maintenance procedure did not require bus maintenance (i.e., visual inspection, cleaning and lubrication of the bus/stab contact surface), allowing degradation to continue unrecognized.

(2) High resistance developed in the connection because of the limited physical engagement of the stab on the bus. The cubicle design allows each bucket some ability to flex. However, this design made proper engagement depth difficult to achieve, especially on large cubicles. A fully engaged stab would have only a 1/8-inch to 3/16-inch overlap on the bus.

The MCC 2B-52 is an ITE 5600 Series MCC that was installed in 1975 at ANO 2 as original plant equipment. The MCC model installed at ANO 2 had a history of problems, including brief fires in the MCC, from 1984 to 2007. The preventive maintenance of the MCC was not adequate. As a result of the October 23, 2007, fire in MCC 2B-52, the licensee took or planned a number of corrective actions, including the following:

- Revise the preventive maintenance procedures to provide guidance for inspecting, cleaning, and lubricating the bus/stab connections, specifically regarding the following actions:

  – Visually inspect the plating on the stab fingers and on the vertical bus at the point where the stab fingers engage the vertical bus. If enough plating has worn off such that bare metal is exposed (copper or aluminum), replace both the stab assembly and the vertical bus.

  – Perform a breaker stab tension inspection of each cubicle.

  – Apply a thin film of NO-OX-ID® grease to the cubicle stabs and contact surface of the bus.

- For the high-risk ITE MCC cubicles, replace the existing stabs with longer ones or install double stabs.

- Replace the existing plated aluminum vertical bus bars with plated copper bus bars for MCC columns with large loads.

Additional information related to the October 23, 2007, event is available in NRC Special Inspection Reports 05000313/2007009 and 05000368/2007009, dated February 27, 2008, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML080590142).

The licensee's root-cause analysis report also discussed another recent fault related to the ITE 5600 Series MCC, which occurred on January 31, 2007, at Calvert Cliffs Nuclear Power Plant. A fault occurred on an ITE 5600 Series MCC because of a high-resistance stab connection on a 50-horsepower motor load caused by degradation of the bus-to-breaker stab connection. The corrective actions taken by the Calvert Cliffs licensee included the installation of double stabs for loads of 50 horsepower and larger and the periodic replacement of stabs.

DISCUSSION

The electrical fire at ANO 2 resulted in the partial loss of one power train of a Class 1E system; however, the opposite power train was still available to provide power to the redundant loads, which would allow for the safe shutdown of the plant. Although the safety significance of this event was not considered high because it impacted only one Class 1E division MCC, the potential for a common-cause failure still existed without the implementation of the proposed corrective actions.

NRC Office of Inspection and Enforcement Circular 77-03, "Fire in a Motor Control Center," dated February 28, 1977, documented two events associated with the ITE 5600 Series MCC. One event happened at Three Mile Island, Unit 2, where an MCC cubicle was not fully inserted and therefore provided only partial engagement of the stabs. The resulting high-resistance connection eventually led to a fire and loss of power from the MCC. The second event, which occurred at the Trojan Nuclear Power Plant, involved misalignment of the stabs.

Licensee Event Report 50-368/2006-001-00, dated December 21, 2006 (ADAMS Accession No. ML070030511), discusses a previous event at ANO 2 involving a small MCC fire. The root cause of this event was determined to be an inadequate MCC design that made it possible to misalign the stabs such that both stab fingers end up on the same side of bus bar resulting in a high resistance connection.

The high resistance of stab connections at the MCC could lead to a fire when large loads are started. The following factors can cause high resistance in these connections:

- oxidation of the aluminum bus caused when the protective coating is worn off over a period of time from the repeated action of the stabs
- poor maintenance practices, including a lack of lubrication at the stabbing contact area
- design deficiencies, such as misalignment of the stabs and insufficient stab contact surfaces

In general, aluminum buses are more prone to oxidation as compared copper buses and therefore to developing high-resistance in stab-type connections. Licensees are encouraged to evaluate the design and anticipated frequency of operations of the loads within MCCs within their facilities and develop preventive maintenance procedures that are appropriate for the application conditions.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contact listed below.

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