

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NEW REACTORS
WASHINGTON, D.C. 20555-0001

June 17, 2016

NRC INFORMATION NOTICE 2016-08: INADEQUATE WORK PRACTICES RESULTING
IN FAULTED CIRCUIT BREAKER
CONNECTIONS

ADDRESSEES

All holders of an operating license or construction permit for a nuclear power reactor under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All holders of and applicants for a power reactor early site permit, combined license, standard design approval, or manufacturing license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." All applicants for a standard design certification, including such applicants after initial issuance of a design certification rule.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of operating experience related to circuit breaker overheating and fires caused by inadequate and high-resistance connections. Information from these events may apply to the design, installation, testing, inspection, and maintenance of circuit breakers. The NRC expects that recipients will review the information for applicability to their facilities, and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

Fort Calhoun Station, Unit 1

On June 7, 2011, at Fort Calhoun Station, Unit 1 a fire occurred in the feeder breaker for a safety-related 480-volt bus. The fire resulted in significant damage to the breaker, bus, and an extended facility shutdown. The fire occurred in a low-voltage breaker that had been installed in 2009 as part of a design modification to replace obsolete breakers. The new breaker assembly consisted of a Square D® breaker and Masterpact® cradle assembly that served as the interface between the breaker and cubicle. Licensee investigation revealed that the main cause of the fire was inadequate engagement of the breaker cradle primary disconnect assembly (PDA) fingers and the bus stabs. Licensee inspection of Masterpact® cradles installed in the other safety-related buses revealed that the fingers on the cradles were longer than the original breaker fingers. The point where the fingers of the new cradle engaged the bus extended past

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the silver-plated portion on the copper bus stab, in an area that contained hardened grease. This likely led to high resistance, overheating, and ultimately the fire. During the design change process associated with the new breaker configuration, the licensee did not consider new failure modes caused by the new finger-stab connections. Additionally, the installation procedures did not require post-modification testing to verify the resistance of the connections between the cradle PDA fingers and bus stabs.

The licensee took corrective actions as a result of this event that included repairing the affected bus, inspecting and testing the other breakers and buses, silver-plating the affected 480-volt bus stabs, and revising maintenance procedures to enhance installation and post-installation inspection.

Additional information regarding this event is available in Licensee Event Report (LER) 05000285-2011-008 Revision 1, dated October 27, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML113010208, and NRC Special Inspection Report 05000285/2011014, dated March 12, 2012 (ADAMS Accession No. ML12072A128).

Browns Ferry Nuclear Plant, Unit 3

On November 4, 2013, an operator at Browns Ferry Nuclear Plant, Unit 3 noted the smell of smoke coming from a 480-volt bus. Further licensee inspection revealed hotspots on the bus feeder breaker. This breaker was a Square D® breaker with Masterpact® cradle assembly (similar to the breaker assembly at Fort Calhoun Station, Unit 1 described above). The bus was transferred to the alternate feeder source, and the normal supply breaker was removed for inspection. The licensee found the cradle PDA fingers discolored from excessive heat. The licensee sent the affected Masterpact® cradle and breaker to the supplier, Nuclear Logistics Inc. (NLI), for failure analysis. NLI determined the direct cause of the overheating primary disconnects was the loss of vertical movement (float) on the primary disconnects of the breaker cradle. The cradle primary disconnects are designed to account for vertical misalignment of the stabs in the switchgear. The primary disconnect fingers have vertical float that maintains the finger pressure on the bus stabs when the bus stabs are not completely aligned in the vertical bus. The loss of vertical float was caused by an incorrectly specified tolerance in the PDA's fabrication drawing. The licensee's installation procedures did not include steps to inspect for freedom of vertical float of the primary disconnects. Additionally, the supplier did not provide guidance for testing freedom of vertical float of primary disconnects.

Because of this event, the licensee performed inspections on the installed Masterpact® cradle assembly PDAs for signs of overheating, and to verify freedom of vertical float of primary disconnects. NLI generated a technical bulletin, and alerted licensees to inspect the affected assemblies for the manufacturing defect, and submitted a report under 10 CFR Part 21, "Reporting of Defects and Noncompliance."

Additional information regarding this event is available in 10 CFR Part 21 Report 2014-09-00, dated February 26, 2014 (ADAMS Accession No. ML14069A467), and NRC Integrated Inspection Report 05000259/2012004, 05000260/2012004, and 05000296/2012004, dated November 13, 2012 (ADAMS Accession No. ML12319A182).

Nine Mile Point Nuclear Station, Unit 2

On August 21, 2015, Nine Mile Point Nuclear Station, Unit 2 used an incorrectly configured grounding cart that caused damage to the line-side connections in a 4160-volt breaker cubicle.

A grounding cart is a device used to apply grounds to switchgear assemblies during maintenance activities to ensure personnel protection. The grounding cart used in this case was configured for-2000 amp stabs versus the 1200-amp stabs required for the breaker cubicle. There was no procedure for ensuring that the stabs on the grounding cart were the proper size for their intended application. As a result, the stabs that were installed on the cart were one inch larger in diameter than the stabs required for the breaker cubicle. The larger stabs caused damage to the draw-out connections on the load side of the breaker cubicle. Workers did not observe the damage following maintenance and removal of the grounding cart, and proceeded with breaker re-installation. When the breaker was re-energized, an arc flash occurred as a result of the damaged connections. This led to loss of the switchgear, loss of an electric fire pump, loss of a feedwater drain pump, and an unplanned 10 percent downpower transient on the reactor. The cause of this event was determined to be the lack of procedural guidance for using the grounding cart in the breaker cubicle.

As a result of this event, the licensee took corrective actions that included implementing procedural guidance to compare the configured grounding cart to the respective breaker cubicle, rather than relying on "skill-of-the-craft" knowledge.

Additional information regarding this event is available in NRC Integrated Inspection Report 05000220/2015003 and 05000410/2015003, dated November 9, 2015 (ADAMS Accession No. ML15314A506).

Palo Verde Nuclear Generating Station, Unit 2

On September 16, 2015, at the Palo Verde Nuclear Generating Station, Unit 2, a breaker arc flash and rapid combustion occurred, resulting in the licensee declaring a Notification of Unusual Event (under the NRC's emergency classification system for grouping off-normal events or conditions). When racking in a non-class 1E load center 480-volt circuit breaker, operators unknowingly caused damage to the breaker's internal connections. During installation, vertical misalignment between the ground clip and ground stab damaged the clip, causing the clip to spread apart as the breaker was racked in. One side of the ground clip came into contact with one of the phases of the line side of the breaker. When the operator locally shut the breaker, an arc flash occurred, causing significant damage to the back door of the cubicle, and creating an occupational safety hazard to the operator. The supply breaker to the bus tripped, de-energizing the fault. This breaker supplied power to non-essential loads, and its failure did not adversely affect the safe operation of the plant. The licensee declared a notification of unusual event as a result of the explosion in the breaker cubicle; however, the operator was dressed out for 4160-volt work, and avoided serious injury. The cause of this incorrect installation was a lack of procedural guidance to verify proper breaker alignment during racking of the breaker. Several months prior, a similar event had occurred on a different breaker at Palo Verde. However, in this event, the ground clip was forced outward instead of inward toward the breaker, and therefore did not come into contact with the phase on the line side of breaker.

The licensee found that misalignment of the breaker ground clip to the cubicle ground stab was limited to ABB K-Line 480-volt circuit breakers. The licensee took corrective actions as a result of the September 16, 2015 event, which included revising procedures to check alignment of the breaker ground clip to cubicle ground stab while racking in 480-volt breakers.

Additional information regarding this event is available in NRC Integrated Inspection Report 05000528/2015003, 05000529/2015003, and 05000530/2015003, dated October 22, 2015 (ADAMS Accession No. ML15295A435).

BACKGROUND

Related NRC Generic Communications

NRC IN 2002-27, "Recent Fires at Commercial Nuclear Power Plants in the United States," dated September 20, 2002 (ADAMS Accession No. ML022630147). The NRC issued this IN to alert addressees of several fire events, one of which was caused by a poor electrical connection between the breaker PDA and the bus stabs.

NRC IN 2007-34, "Operating Experience Regarding Electrical Circuit Breakers," dated October 22, 2007 (ADAMS Accession No. ML072390061). The NRC issued this IN to alert addressees of several circuit breaker problems including deficient fit-ups, inadequate maintenance practices, and issues with design changes.

NRC IN 2008-18, "Loss of a Safety-Related Motor Control Center Caused by a Bus Fault," dated December 1, 2008 (ADAMS Accession No. ML082540130). The NRC issued this IN to alert addressees of an electrical fire caused by a bus fault, which resulted in the loss of safety-related equipment. The fault was caused by inadequate contact of a motor control center's stab fingers to its bus bars.

NRC IN 2010-25, "Inadequate Electrical Connections," dated November 17, 2010 (ADAMS Accession No. ML102530012). The NRC issued this IN to alert addressees of operating experience involving loose electrical connection that resulted in unanticipated plant transients and failures or unavailability of safety-related equipment.

DISCUSSION

Circuit breakers are relied upon to provide electrical power to equipment credited in accident analyses. Industry operating experience has shown that effective breaker maintenance procedures should include provisions to ensure proper alignment during installation, and steps to ensure that there are no high resistance connections in the interface between breakers and electrical buses following breaker installation. The examples provided in this IN illustrate how inadequate breaker connections can result in adverse impacts to safety-related equipment, introduce occupational safety concerns, and present fire hazards. These examples illustrate the importance of adequate breaker testing, inspection, maintenance procedures, and the proper licensee oversight of physical modifications to circuit breaker designs.

CONTACTS

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contact listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

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Note: NRC generic communications may be found on the NRC public Web site, <http://www.nrc.gov>, under Electronic Reading Room/Document Collections.

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