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

January 10, 2002

NRC INFORMATION NOTICE 2002-04: WIRE DEGRADATION AT BREAKER CUBICLE DOOR HINGES

Addressees

All holders of licenses for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to inform addressees of degraded breaker cubicle wires found at the Diablo Canyon nuclear power plant. These wires connect electrical equipment mounted on cubicle doors to equipment inside the breaker cubicles. Over time, the wires degraded due to cold-working and aging. It is expected 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 information notice are not NRC requirements; therefore, no specific actions or written response is required.

Description of Circumstances

On March 14, 2001, at Diablo Canyon, Unit 2, functional testing of relays associated with containment spray (CS) pump 2-2 indicated that the overcurrent relay would not trip the pump breaker. Troubleshooting revealed a broken wire between the CS pump 2-2 breaker cubicle swingout door and the main 4kV cubicle. The pump was returned to operable status after the broken wire was replaced and other cubicle wires were inspected.

The broken wire was analyzed, and it was determined that a number of wire strands had been broken for some period of time based on the presence of corrosion at the end of the broken strands. After reviewing the finding for potential generic implications, the licensee determined that a 10% sample of 4kV breaker cubicles would be inspected for wire degradation. On March 21-22, 2001, the first three 4kV breaker cubicles from the sample were inspected. Two of the breaker cubicles showed no wire damage, but the third breaker cubicle contained two degraded, but not broken, wires. This breaker cubicle is associated with Unit 1, CS pump 1-1.

On March 23, 2001, it was decided that an inspection of all 4kV breaker cubicles was needed, except where an inspection would be risky with the reactors at power (e.g., 4kV-to-480V feeder breakers and startup crosstie breakers). Subsequent inspections during March 23-28, 2001, revealed four more cubicles with degraded wires, resulting in a total of six cubicles containing degraded wires. Table 1, identifies the cubicle, the type of wire damage, and the effect on the vital 4kV electrical system.

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TABLE 1. DESCRIPTION OF BREAKER CUBICLE WIRE DEGRADATION

Breaker Cubicle Equipment	Description
Containment spray pump 2-2	The overcurrent relay had one completely broken wire.
Containment spray pump 1-1	One wire used for overcurrent protection had exposed and broken strands. A second spare wire had damaged insulation.
Safety injection pump 2-2	A wire associated with overcurrent protection for one of the three phases had broken strands.
Unit 2, bus H auxiliary feeder breaker	Two wires associated with load shedding of residual heat removal (RHR) pump 2-2 and CS pump 2-2 had broken strands.
Unit 1, bus F auxiliary feeder breaker	A wire connecting the ammeter select switch and test cut-out switch had damage to the outer cloth jacket of the insulation.
Diesel generator 1-3 feeder breaker	Two wires associated with the ground sensor auxiliary relay and alarm had broken strands. A third abandoned wire also had broken strands.
Component cooling water pump 2-1	A wire providing power to an indicating lamp had damaged outer insulation, although the inner insulation was still intact.

Of the degraded wires found in the six cubicles, only the broken wire associated with CS pump 2-2 was found to impact the 4kV electrical distribution system. If an overcurrent condition occurred on CS pump 2-2, the broken wire would prevent the overcurrent relay from opening the breaker, resulting in potential damage to the pump motor and/or loss of the associated vital 4kV bus. Submitting the other degraded wires to a 5-ampere current for one minute proved them able to carry out their respective functions. A 5-ampere current is the maximum current expected for any of the degraded wires.

Discussion

Breaker Cubicle Arrangement and Wire Type

The broken wire removed from CS pump 2-2 breaker cubicle was AWG #12, Type TA insulation, National Electrical Manufacturers Association (NEMA) Class K (high strand) copper wire. This wire has an inner rubber-type jacket and an outer fibrous jacket. The degraded wires found in the other breaker cubicles were of similar type, but some were of a different gauge. The breaker cubicles and the components inside them, including the wires, were bought from General Electric and installed circa early 1970s during plant construction.

The vital Class 1E 4kV breaker cubicles are General Electric Type M-26 breaker cubicles that have two swingout doors. The bottom swingout door accesses the breaker and the top swingout door accesses the breaker controls. Various relays, controls, and indications are mounted on the top swing-out door. The number and type of equipment mounted on the top swingout door depend on the type of plant equipment powered through the breaker. The number of pieces and type of equipment mounted on the top swingout door also determines the number of wires connecting the door-mounted equipment with terminals inside the cubicle (typically 40 to 100 wires.)

The wires connecting the door-mounted equipment with terminals inside the cubicle are supported by two vertical wire braces (also called wire looms) as shown in Attachment 1. The purpose of the wire looms is to prevent the wires from becoming pinched in the door hinge when the breaker is opened and closed. One wire loom is mounted on the swingout door approximately 6 inches off the door surface and 2 inches from the door hinge. The other wire loom is mounted inside the cubicle approximately 10 inches from the door hinge and approximately 2 inches off the inner cubicle wall. The figure shows the construction and the location of the wire loom in relation to the door, door hinge, and other breaker components. When the door is fully opened, there is approximately 2 to 10 inches of wire slack between the two wire braces.

Root Cause

The licensee has performed a formal evaluation to determine the cause of the breaker cubicle wire degradation. The evaluation indicates that cold working and aging of the wires are the causes.

(1) Cold Working
In a wire loom layout, in certain cases the wires are forced into the side of the breaker cubicle when the cubicle door is closed. This can force the wire on the inside of the bend to exceed the minimum bend radius for a dynamic bend, resulting in cold-working of the strands. Subsequent cycling of the door eventually results in wire failure.

(2) Age-related degradation of the wires
Over time, the plasticizer leaches out of the PVC insulation, resulting in embrittlement. Flexing of the wire causes the insulation to break. The loss of the mechanical support provided by the insulation focuses the bending at the break, speeding the cold working of the wire strands and causing eventual failure.

Corrective Actions

All degraded wires that have been identified have been replaced, and a continuity test has been performed to ensure that the wires are connected to the correct terminals and functional. The licensee is currently planning to inspect other wires in the plant that are susceptible to cold working and age-related degradation using a risk-informed work schedule. Specifically, the licensee is carrying out the following modifications.

(1) Redesign the breaker cubicle wire looms and/or wire loom supports to eliminate excessive bending at the door hinge area.

(2) Replace the wires that span the breaker cubicle hinge areas with standing class K or S wire that uses contemporary insulation (non-PVC).

This information notice requires no specific action or written response. If you have any questions regarding the information notice, please contact the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

/RA/
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Attachments:
1. Breaker Cubicle Interior
2. List of Recently Issued NRC Information Notices

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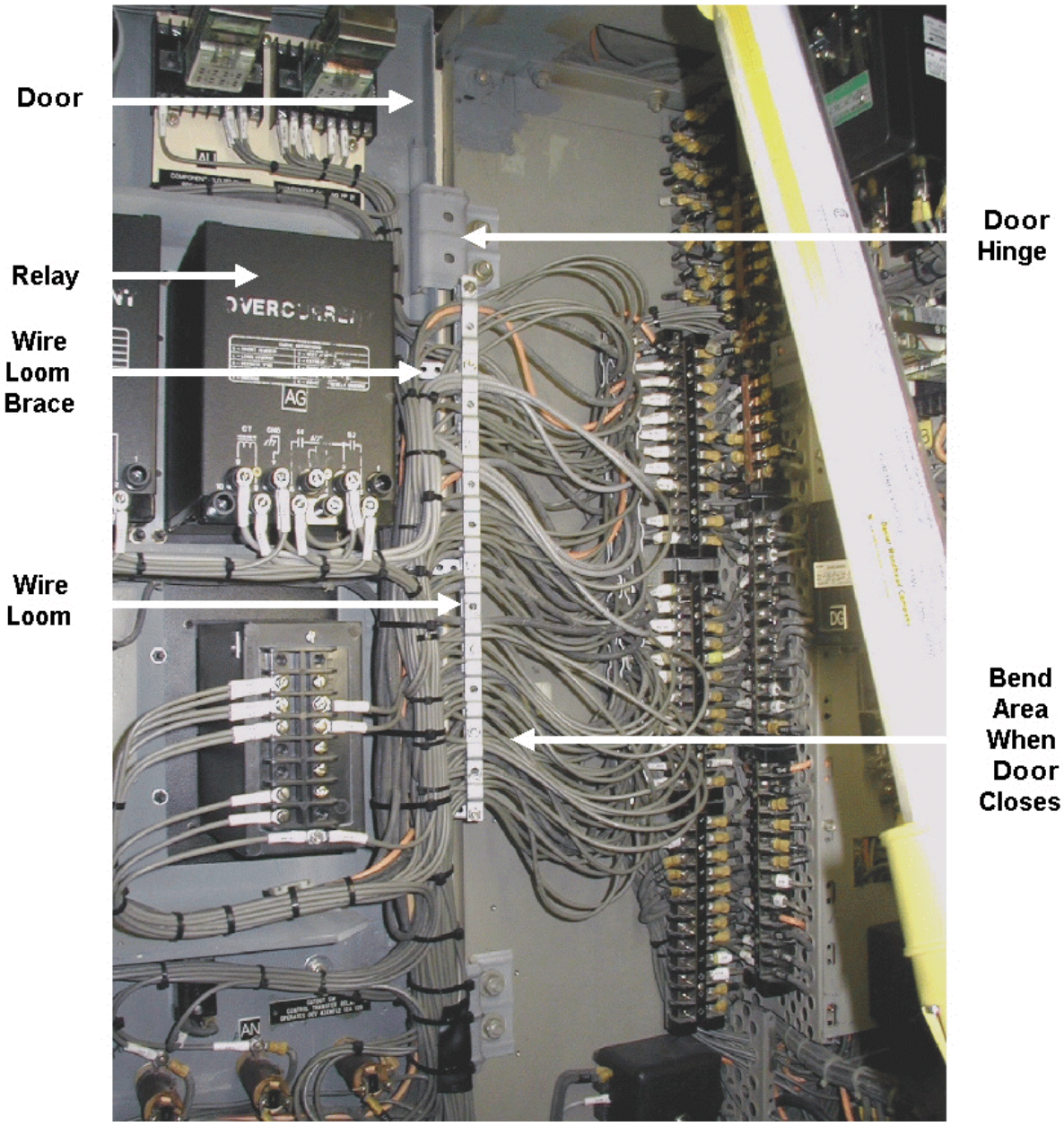

Breaker Cubicle Interior

LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
2002-03	Highly Radioactive Particle Control Problems During Spent Fuel Pool Cleanout	1/10/2002	All holders of operating licenses for nuclear power reactors, holders of licenses for permanently shutdown facilities with fuel onsite, and holders of licenses for non-power reactors.
2002-02	Recent Experience with Plugged Steam Generator Tubes	01/08/2002	All holders of operating licenses for pressurized-water reactors (PWRs), except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor.
2002-01	Metalclad Switchgear Failures and Consequent Losses of Offsite Power	01/08/2002	All holders of licenses for nuclear power reactors.
2001-19	Improper Maintenance and Reassembly of Automatic Oil Bubblers	12/17/2001	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.
2001-18	Degraded or Failed Automated Electronic Monitoring, Control, Alarming, Response, and Communications Needed for Safety and/or Safeguards	12/14/2001	All uranium fuel conversion, enrichment, and fabrication licensees and certificate holders authorized to receive safeguards information. Information notice is not available to the public because it contains safeguards information.

OL = Operating License
CP = Construction Permit