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

March 12, 1997

NRC INFORMATION NOTICE 97-08: POTENTIAL FAILURES OF GENERAL ELECTRIC MAGNE-BLAST CIRCUIT BREAKER SUBCOMPONENTS

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to potential failures of six subcomponents in General Electric (GE) type AM or AMH 4.16-kV circuit breakers that can render the breakers inoperable. The subcomponents in question are (1) the trip crank, (2) the CR2940 contact blocks that make up the power switch assembly, (3) the manual trip lever and its supporting "L" bracket in the AMH horizontal drawout breakers, (4) the cotter pin that holds the latch pawl hinge pin in place, (5) the spring charging motor tie bolts, and (6) the type HMA control relay. 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 action or written response is required.

Description of Circumstances

Trip Crank Failures

The NRC has learned that several plants have experienced failures of the trip crank (GE Part No. 105C9316G1, Piece No. 28 of Figure 1 in GE ML-13 Mechanism Renewal Parts Bulletin GEF-4379) in Magne-Blast circuit breakers. These failures occurred when the pin at the end of the crank broke off. The pin may break off the crank when the trip coil is energized. The trip crank pin inserts into a hole in the lower end of the link between the trip crank and the trip coil armature. If the pin breaks off before the trip crank can successfully rotate the trip shaft (which has been the case in most instances), the breaker will fail to trip electrically (although it can still be tripped with its local manual pushbutton).

Discussion

Trip Crank Failures

GE has attributed the broken pins to three principal factors: (1) lack of adequate control of one of the critical machined dimensions on the pin during the early 1970s, (2) lack of adequate fusion in some of the pin-to-plate welds, and (3) grinding of the weld reinforcements flush on the back of the trip crank plates. Upon being informed of the first instances of pin failure in 1988 (at Tennessee Valley Authority's Watts Bar Nuclear Plant), GE instituted more rigorous quality control checks on the pins and finished trip cranks. GE also revised the pin weld detail on its trip crank fabrication drawing (105C9316) and added "DO NOT GRIND FLUSH." Several failures were reported after the initial Watts Bar report, and many potentially susceptible breakers were found in the field, all with their original trip cranks made in the early 1970s. However, no instances of failures of trip cranks manufactured after 1988 have been reported.

Also, if the remote trip signal (either from a protective relay or a manual hand switch) is applied for more than a few seconds (which it normally is) and the breaker fails to trip (such as it would if the trip crank pin broke), neither the breaker-mounted auxiliary switch nor the stationary (cubicle-mounted) auxiliary switch will signal control circuits that the breaker has opened, and thus the trip signal will normally remain applied. Energizing the trip coil (which is normally energized only momentarily) for an extended period may open-circuit the coil, thereby rendering it permanently inoperable.

Trip cranks that are potentially susceptible to this failure can be identified without disassembly of the breaker mechanism. With the mechanism front cover removed, the gap between the trip crank and the right side of the mechanism frame may be seen. It is then possible to see whether the weld reinforcement has been ground off. GE is preparing a service advisory letter (SAL) on this problem in which it intends to recommend replacement of any trip cranks that do not have the proper thickness of pin weld reinforcement (1/32-1/16 inch). GE Philadelphia Operation (GE PO) can furnish replacement cranks.

Description of Circumstances

Contact Block CR2940 Contact Resistance

On February 12, 1996, the FitzPatrick licensee experienced failure of two residual heat removal service water (RHRSW) pumps to start on demand because their supply breakers failed to close. RHRSW pump C failed to start on demand during monthly surveillance testing and RHRSW pump A failed to start when attempting to place it in service as part of a suppression pool cooling evolution. The licensee's investigation found that the Magne-Blast breakers failed to close because high resistance across one of the power switch assembly contacts prevented the closing coil from being energized.

Discussion

Contact Block CR2940 Contact Resistance

The power switch assembly consists of three GE type CR2940 contact blocks stacked together so that all three sets of contacts are actuated by a single striker. Two of the contacts (1-2 and 3-4) are normally open and are held closed by the striker during the spring charging operation. When the charging cycle is complete, the contacts spring-return to the open position to cut off power to the spring charging motor and the control (anti-pump) relay (52Y). The third set of contacts (5-6) is normally closed and is included as an option to allow remote indication of the closing spring status (charged/discharged), usually by means of a white indicator light in the control room. This third contact is often called the "white light" contact for this reason. This contact is wired into the breaker control circuitry such that failure of the contact to close will prevent the breaker closing coil (52X) from being energized and the breaker cannot be closed electrically.

The licensee determined that the CR2940 contacts were misapplied in the Magne-Blast breaker control circuitry because the contacts are rated for only 2.2 amps dc and are required to interrupt 6.0 amps dc (Licensee Event Report 50/333 96-002, Accession No. 960410298). The licensee also observed that the contacts seemed to show signs of arcing (blackened, pitted surface) after about 2,000 operations, even though the recommended breaker service life is 10,000 operations. General maintenance instructions in GE Technical Manual GEI-88771D, "Magne-Blast Circuit Breaker," states that the 1,200-amp breakers are capable of performing up to 5,000 operations and the 2,000-amp breakers are capable of performing 3,000 operations before any replacement of parts should be necessary.

Resistance measurements across the failed contacts varied between 200-1000 ohms. Contacts with 1,500 operations or less did not have the arcing indications, nor did they have high resistance readings. The licensee also noted that there were no recommendations to check the contact resistance during periodic preventive maintenance in the vendor's maintenance manual. There was disagreement between the plant's drawings and the manufacturer's wiring diagrams. The manufacturer's wiring diagram indicates that the 5-6 contact should be jumpered out when not used. One of the plant drawings shows that when the 5-6 contact is "not furnished," it should be jumpered. The 5-6 contact is not shown at all on the plant RHRSW pump circuit breaker elementary drawing.

The FitzPatrick licensee has also experienced failure of CR2940 contact blocks used as latch checking switches in Magne-Blast breakers, even though the contacts do not experience significant "make" or "break" current. The licensee believes that these failures could be related to aging or the number of operations and is evaluating whether periodic replacement may be necessary.

In a letter dated June 14, 1996, GE Nuclear Energy informed the FitzPatrick licensee that the suitability of the CR2940 contact blocks in the ML-13 operating mechanism for the Magne-Blast breaker was confirmed by testing the breaker in accordance with applicable American National Standards Institute (ANSI) and National Electrical Manufacturers Association

(NEMA) standards. Operability of the contacts was demonstrated by breaker life cycle testing of 10,000 operations with no failure of the contact blocks, and there is no requirement to replace the contacts on the basis of age or the number of operations. However, GE stated that according to applicable NEMA standards, the maximum number of operations between servicing is 2,000. The operations are listed on the basis of servicing at intervals of 6 months or less. GE also stated that although the published instructions do not specifically address the contact block resistance, instructions for checking the control power during servicing include measuring the operating voltage at the closing coil, the trip coil, and the charging motor terminals. GE believes that this type of testing would reveal whether the contacts required replacement. GE stated that the wiring diagram clearly indicates that the 5-6 contact should be jumpered out when the "white light" function is not utilized. In addition, the drawing shows that another CR2940 contact used as a latch check switch in the closing coil circuit should also be jumpered out when this feature is not used.

GE concluded that although the contact blocks were suitable for use in the Magne-Blast breakers, the operability demands of the nuclear power industry and the recently reported problems from the field indicated that the contact blocks were a weak link in the design of the control circuitry. GE recommended the following actions in the June 14, 1996 letter:

- In control schemes where the "52 SM/LS" (5-6) contact is installed but not utilized, it should be jumpered out of the circuit.

- In control schemes where the "52 SM/LS" (5-6) contact is installed and utilized for "white light" indication, but the "auto reclose" function is not used, the wiring should be revised to remove the contact from the close coil circuit. GE can furnish a revised wiring diagram and nameplate.

- For the CL/MS application, where the contact block is used to break charging motor current, GE is evaluating a replacement device. The new switch will have a higher dc interrupting rating and will be furnished for those applications where breaker applications require the increased durability.

GE plans to issue a SAL concerning the CR2940 contact blocks in March 1997.

Description of Circumstances

Bent Manual Trip Lever and Cracked "L" Bracket

During surveillance testing in June and July 1996, the licensee for Calvert Cliffs identified two problems with type AMH-4.76-250 (horizontal drawout) Magne-Blast circuit breakers. In the first case, a low-pressure safety injection (LPSI) pump breaker failed to close. The licensee found that the trip lever was bent and there was no gap between the trip lever and the manual trip rod. Although no gap value is given in the vendor manual, there is generally a small gap between the trip lever paddle and the manual trip rod. The bent trip lever prevented the trip latch from fully rotating onto the stop pin, resulting in a less than optimal

area of contact (wipe) between the latch and the stop pin. As a result, the breaker would experience intermittent failure to close.

A second LPSI pump circuit breaker failed to close during monthly testing at Calvert Cliffs in July 1996. Investigation found that in addition to the trip lever's being bent, the "L" bracket support for the trip lever was also cracked. The "L" bracket is designed to support the trip lever and provide additional stiffness. A subsequent inspection of other breakers at Calvert Cliffs found that one other breaker had a bent trip lever and two other breakers had cracked "L" brackets.

Discussion

Bent Manual Trip Lever and Cracked "L" Bracket

GE performed extensive testing on one of the failed Calvert Cliffs breakers and concluded that the most probable cause was insufficient trip latch reset spring force caused by either incorrect or damaged springs originally installed at the factory. GE recommended a modification to the Calvert Cliffs breakers to prevent further cases of trip lever bending and "L" bracket failures. The modification consists of replacing the trip paddles, the support bracket, and the spring discharge link. The trip lever material was changed from American Iron and Steel Institute (AISI) 1005 carbon steel to AISI 1018 carbon steel. The "L" bracket was changed from AISI 1005 steel to aluminum. The configuration of the components was also changed.

The modification corrects for the weak spring and allows the breaker to retain operability with the weak spring installed. Replacement of the trip latch reset spring is not part of the normal maintenance or overhaul activity. Replacement of the spring requires that a V-notch be cut into the breaker angle support to allow removal of the trip shaft. The Calvert Cliffs licensee plans to replace the weak springs in the breakers during the next scheduled overhaul.

The modification kit is available as Catalog No. 0172C8186G001. GE plans to issue a SAL on this issue by April 30, 1997.

Description of Circumstances

Cotter Pins for the Latch Pawl Hinge Pin and Charging Motor Tie Bolts

On September 13, 1996, the licensee for Vermont Yankee Nuclear Power Station discovered during a tagging procedure that the "A" emergency diesel generator (EDG) was inoperable. The EDG output circuit breaker (GE type AM-4.16 kV Magne-Blast) was found in its normally open position, but its closing springs were discharged. With the springs discharged, the breaker was incapable of closing.

Subsequent investigation by the Vermont Yankee licensee determined that the spring charging motor had run to failure because the cotter pin that holds the latch pawl hinge pin in position broke. The ears of the cotter pin had apparently broken and allowed the cotter pin

to fall out, thus allowing the hinge pin to work its way out of position and prevent the latch pawls from holding the ratchet wheel in place during the charging operation. The charging springs were not compressed, and the charging motor continued to run until it overheated and the motor winding open-circuited. Three of the four charging motor tie bolts that connect the motor portion to the gear housing were also found lying on the floor of the breaker cell. Vermont Yankee personnel inspected other similar breakers and found that 18 cotter pins were either degraded (one or both "ears" broken off) or undersized, and in one case a cotter pin was missing from the latch pawl hinge pin. Three breakers were also found with one or more loose charging motor tie bolts.

On November 25, 1996, after learning of the event at Vermont Yankee, the licensee for FitzPatrick performed an inspection and identified 10 out of 18 safety-related Magne-Blast breakers with degraded cotter pins latch pawl hinge pins. Similar to the failure at Vermont Yankee, the cotter pins had one or both ears broken off. One undersized cotter pin was also found, but it was not broken and the licensee determined that it had been installed by plant personnel.

Discussion

Cotter Pins for the Latch Pawl Hinge Pin and Charging Motor Tie Bolts

The latch pawl hinge pin was originally designed in 1962 to be held in place by cotter pins at either end. In 1979, GE enhanced the design of the hinge pin assembly by tapping an existing hole in the hinge pin support bracket and installing a bolt with a washer large enough to overlap the hinge pin. Using the bolt and washer to hold the hinge pin in place precluded the need for cotter pins. According to GE, this enhancement was made only to aid in disassembly and reassembly of the breaker during maintenance, and not because of any perceived problem with the cotter pins. As a result, GE did not deem it necessary to inform customers of the change in 1979. Testing performed by GE in 1996 demonstrated that the cotter pins may experience damage after approximately 2,000 operations. GE plans to issue a SAL on this issue in March 1997.

Two different styles of charging motors are used in Magne-Blast breakers. Initially, GE used motors manufactured by the Sioux Tool Company of Sioux City, Iowa. In the early 1970s, GE switched to motors made by Millers Falls (later bought by Ingersoll/Rand). In the late 1970s, GE went back to using the Sioux Tool Company as the charging motor supplier for the Magne-Blast breakers and still uses it today when customers order replacements.

The two different types of charging motor can be easily identified. Two black cover plates conceal the tie bolts on the Sioux motors, and thus the bolts are not visible from the outside. The cover plates have to be removed to gain access to the four bolt heads, and the tie bolts are inserted from the motor housing into the gear housing. In contrast, the tie bolts on the Millers Falls (Ingersoll/Rand) motors have exposed heads and are inserted from the gear housing into the motor housing. The motors with the loose bolts at Vermont Yankee were Millers Falls motors.

Description of Circumstances

Type HMA Control Relay

On December 1, 1996, a Magne-Blast breaker serving as a vital bus feed breaker failed to close on demand during surveillance testing at Salem Nuclear Generating Station. The licensee determined that the HMA control relay (the anti-pump relay [52Y]) normally closed contacts failed to reclose when the relay was deenergized because of binding of the armature against the molded phenolic post. With the contacts stuck in the open position, the closing circuit cannot be completed and the breaker cannot be closed electrically.

Discussion

Type HMA Control Relay

The relay was sent to the vendor (GE Power Management [GE PM], Malvern, Pennsylvania) for detailed failure analysis. The vendor found that there was no clearance between one side of the armature tailpiece and the molded post. Normally, when an HMA relay is assembled at the factory, the armature is centered between the two molded posts with a gap of 0.005 inch on each side.

The vendor recalled that a similar situation occurred in 1982 and prompted the issuance of SAL 721-PSM No. 171.1, "HMA Relay Armature Binding," on December 17, 1982. The original SAL stated that a tool problem at the factory in 1974 caused several relays to have improper clearance between the armature and the molded posts. The SAL suggested that the proper clearance could be achieved by first removing the armature stop clamping nut and lifting the stop and armature tailpiece from between the molded posts, and then removing some of the phenolic post material.

The NRC discussed this issue with GE PM. The vendor stated that the armature could be checked for the proper clearance between the armature and the molded posts by use of feeler gauges. A gap of less than 0.002 inch on either side indicates an adjustment is needed. However, the original SAL stated that the solution was to remove some of the phenolic material from the posts and did not mention that customers could first try to adjust the armature to achieve the proper clearance. If the relay does not have the proper clearance, usually all that is needed is to loosen the armature stop clamping nut, center the armature between the two posts, retighten the nut, and then check the clearances again. The vendor also stated that although the recommended minimum gap given in the original SAL is 0.005 inch on each side, a gap of 0.002 inch is considered adequate for reliable operation.

Related Generic Communications

GE issued SAL 073-352.1, "Latest Design Configuration: GE Type AM Circuit Breakers and Medium Voltage Switchgear," on July 7, 1995, to alert customers to design changes made in the circuit breakers, their operating mechanisms, and the switchgear. Some of the listed design changes were discussed in previous SALs, while other changes were not originally conveyed to customers because the changes were made to facilitate assembly, maintenance,

or operation of the equipment. The SAL states that customers should evaluate each item listed and consider the applicability to their particular equipment.

Recent NRC information notices (Ins) concerning Magne-Blast circuit breakers are as follows:

IN 90-41, "Potential Failure of General Electric Magne-Blast Circuit Breakers and AK Circuit Breakers," issued June 12, 1990.

IN 93-91, "Misadjustment Between General Electric 4.16-kV Circuit Breakers and Their Associated Cubicles," issued December 3, 1993.

IN 94-54, "Failure of General Electric Magne-Blast Circuit Breakers to Latch Closed," issued August 1, 1994.

IN 96-43, "Failures of General Electric Magne-Blast Circuit Breakers," issued August 12, 1996.

IN 96-46, "Zinc Plating of Hardened Metal Parts and Removal of Protective Coatings in Refurbished Circuit Breakers," issued August 12, 1996.

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

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Information Notice No.	Subject	Date of Issuance	Issued to
97-07	Problems Identified During Generic Letter 89-10 Closeout Inspections	03/06/97	All holders of OLs or CPs for nuclear power reactors
97-06	Weaknesses in Plant-Specific Emergency Operating Procedures for Refilling the Secondary Side of Dry Once-Through Steam Generators	03/04/97	All holders of OLs or CPs for nuclear power reactors with with once-through steam generators
91-85, Rev. 1	Potential Failures of Thermostatic Control Valves or Diesel Generator Jacket Cooling Water	02/27/97	All holders of OLs or CPs for nuclear power reactors
97-05	Offsite Notification Capabilities	02/27/97	All holders of OLs or CPs for nuclear power reactors and test and research reactors
97-04	Implementation of a New Constraint on Radioactive Air Effluents	02/24/97	All materials, fuel cycle, and non-power reactor licensees
97-03	Defacing of Labels to Comply with 10 CFR 20.1904(b)	02/20/97	All material licensees involved with disposal of medical waste

OL = Operating License
CP = Construction Permit

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