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

March 26, 1993

NRC INFORMATION NOTICE 93-22: TRIPPING OF KLOCKNER-MOELLER MOLDED-CASE CIRCUIT BREAKERS DUE TO SUPPORT LEVER FAILURE

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 the potential for spurious tripping of certain Klockner-Moeller (K-M) molded-case circuit breakers (MCCBs) under no-load or normal load conditions. The trips resulted from failure of switch latch support levers (support levers). 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

On July 1, 1992, Virginia Electric and Power Company (VEPCO), licensee for North Anna Power Station (North Anna), Units 1 and 2, reported to the NRC pursuant to Part 21 of Title 10 of the Code of Federal Regulations (10 CFR Part 21) that over a three-month period in 1992, three K-M model NZM6-63, 480-Vac MCCBs had tripped without appreciable load or fault condition or other electrical or mechanical transient. The three failed MCCBs were located in the cable vault and tunnel area of North Anna-2 and supplied power to motor operated valves in the charging and safety injection systems. The switch handles were found in the trip-free position and the breakers could not be relatched and reclosed.

Discussion

Examination of the internals of one of the three failed breakers revealed that its support lever (also described by VEPCO as a "spring arm"), located in the rear compartment of the case, had fractured. This caused the breaker to trip and to become incapable of being reclosed. These MCCBs were part of a group of similar breakers manufactured in Germany by Klockner-Moeller in 1972 and supplied to VEPCO in K-M Series 170 motor control centers.

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The NRC has determined that the support levers only in K-M model NZM6, NZM6b, and NZMH6 MCCBs, rated for 100 amperes and below and manufactured from 1972 on, have been made of the same type of plastic used in the support levers of the MCCBs that failed at North Anna-2.

According to a VEPCO Material Engineering Laboratory report, the failed support levers are made of a polycarbonate-glass fiber composite material. The VEPCO laboratory performed infrared spectroscopy, scanning electron microscopic examination and associated energy-dispersive-X-ray spectroscopic (EDS) analysis on the support lever from the MCCB examined at North Anna. It also conducted tests of and comparison with the same part from two other MCCBs that had been in service, but had not failed. On the basis of this testing, the VEPCO laboratory concluded that the fracture in the failed support lever it examined was related to the number of stress cycles experienced and that cracks initiated at the inside of a shaft hole in the support lever. Although the breakers have a design life of 20,000 cycles (opening and closing), the three failed MCCBs had been cycled only a few times a year and have been in service since about 1977. The VEPCO laboratory results suggested that similar MCCBs exposed to similar service conditions as these might fail in a similar manner.

Klockner-Moeller submitted to VEPCO and to the NRC the report from its German factory laboratory (with English translation) of the examination and analysis of two of the three failed MCCBs. The report concluded that the fractures in the support levers resulted from stress cracking caused by mechanical loads inside the circuit breaker and possibly environmental influences, e.g., chlorinated hydrocarbons. Although the VEPCO laboratory did not find evidence of contaminants of this type, the K-M lab report suggested that a source of contaminants could be off-gassing associated with arc extinguishing.

During a recent inspection at the Klockner-Moeller U.S. corporate offices, the NRC reviewed a Wyle Laboratories aging report on certain K-M equipment including model NZMH6 MCCBs (rated for 100 amperes and less). The report indicated that the support lever in one of these MCCBs (made of the same material as those that failed at North Anna) failed in a similar manner after excessive accelerated thermal aging. The model NZMH6 in which the support lever failed had been aged for a total of 2280 hours at 125 °C [257 °F], indicating that a support lever of the same material could fail after an equivalent amount of thermal aging degradation. However, other model NZMH6 MCCBs, rated at 100 amperes or less, did not fail after aging at 125 °C [257 °F] for 1104 hours. These latter aging parameters were intended to simulate 18 years at an average ambient service temperature of 59 °C [138 °F]. This ambient service temperature assumed a 40 °C [104 °F] ambient temperature with a heat rise of 19 °C [34 °F].

Using the accellerated thermal aging parameters and postulated service temperature and life of the MCCBs that did not fail, an activation energy can be determined and used to calculate an approximate expected service life (with an equivalent amount of thermal aging degradation) at any given ambient

service temperature. Similarly, using the same activation energy derived in the first calculation, and using the thermal aging parameters of the failed MCCB at a given ambient temperature, an approximate service life can be determined for which acceptable breaker performance is less certain.

VEPCO has reported that the failed MCCBs at North Anna had been subjected to room ambient temperature averaging between about 38 °C [100 °F] and 49 °C [120 °F] in the summer for about 13 years. When air conditioning was installed in 1990, the average ambient temperature in this area was reduced to about 27 °C [80 °F]. The heat rise at these MCCBs was not reported, but the MCCBs were not normally under more load than that of valve position indicating lights. The Klockner-Moeller failure analysis assumed a lifetime ambient temperature of only 27 °C [80 °F]. However, because the amount of thermal degradation alone that would be expected in the support levers that failed at North Anna under these conditions is less than that experienced by the Wyle specimens that did not fail, and because the breakers in both instances had been cycled much less than the design limit, the presence of some other factor(s) in the North Anna case is suspected.

VEPCO has made inquiries regarding these MCCBs on the Nuclear Network and other industry forums. Five utilities that had similar MCCBs, for nonsafety related applications and safety-related applications, responded that they did not have records of similar failures. The manufacturer records indicated that similar K-M model MCCBs were sold to six nuclear utilities for safety-related applications. Others have been sold as commercial grade through distributors. However, K-M stated that they had not received reports of similar failures.

The proximate cause of the failures at North Anna is generally agreed upon by the parties involved to be cyclic stress fatigue. However, the lack of other failures in the industry also suggests that other contributing factors such as temperature or chemical exposure may need to be present to cause failure with so few cycles. More rapid than expected thermal aging or chemical exposure, or a combination of the two (possibly with synergistic effects), may cause weakening or embrittlement of the material in the support lever of 100-amp or less-rated NZM6, NZM6b, and NZMH6 K-M model MCCBs such that the support lever can fail prematurely, i.e., with significantly fewer cycles than the design value.

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

Brian K. Grimes, Director
Division of Operating Reactor Support
Office of Nuclear Reactor Regulation

Technical contact: Stephen Alexander, NRR
(301) 504-2995

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List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
93-21	Summary of NRC Staff Observations Compiled during Engineering Audits or Inspections of Licensee Erosion/Corrosion Programs	03/25/93	All holders of OLs or CPs for light water nuclear power reactors.
93-20	Thermal Fatigue Cracking of Feedwater Piping to Steam Generators	03/24/93	All holders of OLs or CPs for PWRs supplied by Westinghouse or Combustion Engineering.
93-19	Slab Hopper Bulging	03/17/92	All nuclear fuel cycle licensees.
93-18	Portable Moisture-Density Gauge User Responsibilities during Field Operations	03/10/93	All U.S. Nuclear Regulatory Commission licensees that possess moisture-density gauges.
93-17	Safety Systems Response to Loss of Coolant and Loss of Offsite Power	03/08/93	All holders of OLs or CPs for nuclear power reactors.
93-16	Failures of Nut-Locking Devices in Check Valves	02/19/93	All holders of OLs or CPs for nuclear power reactors.
93-15	Failure to Verify the Continuity of Shunt Trip Attachment Contacts in Manual Safety Injection and Reactor Trip Switches	02/18/93	All holders of OLs or CPs for nuclear power reactors.
93-14	Clarification of 10 CFR 40.22, Small Quantities of Source Material	02/18/93	All licensees who possess source material.
93-13	Undetected Modification of Flow Characteristics in the High Pressure Safety Injection System	02/16/93	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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Original signed by
Brian K. Grimes

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*D:DRIL:NRR CERossi 02/03/93	*OGCB:DORS:NRR NCampbell 02/16/93	*OGCB:DORS:NRR GHMarcus 03/10/93	D:DORS:NRR BKGrimes 03/22/93
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K-MBKG.IN

*SEE PREVIOUS CONCURRENCES DOCUMENT NAME: ~~KLOCKCBS.IN~~

*VIB:DRIL:NRR	*VIB:DRIL:NRR	*VIB:DRIL:NRR	*DD:DRIL:NRR
SAlexander:mkm	GCwalina	LNorrholm	RZimmerman
01/04/93	01/26/93	01/27/93	02/08/93
*D:DRIL:NRR	*OGCB:DORS:NRR	*OGCB:DORS:NRR	D:DORS:NRR
CERossi	NCampbell	GHMarcus	BKGrimes
02/03/93	02/16/93	03/10/93	03/ /93
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The proximate cause of the failures at NARS2 is generally agreed to be cyclic stress fatigue. However, the lack of other failures in the industry suggests that other contributing factors may need to be present to cause failure with so few cycles. In particular, more rapid than expected thermal aging and possible chemical exposure can cause weakening or embrittlement of the material in the support lever of 100-amp or less-rated NZM6, NZM6b, and NZMH6 K-M MCCBs such that the support lever can fail prematurely, i.e., with significantly fewer cycles than the design value.

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SAlexander:mkm	GCwalina	LNorrholm	RZimmerman
01/04/93	01/26/93	01/27/93	02/08/93
*D:DRIL:NRR	*OGCB:DORS:NRR	OGCB:DORS:NRR	D:DORS:NRR
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DATE	1/04/93*	1/26/93*	1/27/93*	2/ 8 /93	2/ 3 /93
COPY DOC	YES xx	YES xx	YES xx	YES NO	XXX NO

OFFICE	OGCB/DORS	OGCB/DORS	DORS/NRR	ADM/RPB0	
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DATE	1/04/93*	1/26/93*	1/27/93*	2/ 8 /93	2/3 /93
COPY DOC	YES xx	YES xx	YES xx	(YES) NO	XXX NO

OFFICE	OGCB/DORS	OGCB/DORS	DORS/NRR	ADM/RPB0	
NAME	NCAMPBELL	GMARCUS	BKGRIMES	JMAIN	
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DATE	1/04/93*	1/26/93*	1/27/93*	2/3 /93	2/3/93
COPY DOC	YES xx	YES xx	YES xx	(YES) NO	YES NO

OFFICE	OGCB/DORS	OGCB/DORS	DORS/NRR	ADM/RPB	
NAME	NCAMBELL	GMARCUS	BKGRIMES	JMAIN	
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NAME	SALEXANDER	GCWALINA	LNORRHOLM	RZIMMERMAN	CEROSSI
DATE	~~1/04/93*~~ 1/26/93	1/24/93	1/27/93	1/ /93	1/ /93
COPY DOC	YES NO	YES NO	YES NO	YES NO	YES NO

OFFICE	OGCB/DORS	OGCB/DORS	DORS/NRR	ADM/RPB	
NAME	NCAMBELL	GMARCUS	BKGRIMES	JMAIN	
DATE	1/ /93	1/ /93	1/ /93	1/5/93*	
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