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

August 1, 1994

NRC INFORMATION NOTICE 94-54: FAILURES OF GENERAL ELECTRIC MAGNE-BLAST CIRCUIT BREAKERS TO LATCH CLOSED

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 a condition in which certain General Electric (GE) medium-voltage Magne-Blast circuit breakers may begin to randomly fail to latch closed. 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

The Maine Yankee Atomic Power Station (Maine Yankee) and the Millstone Nuclear Power Station (Millstone) have recently experienced failures of safety-related GE Magne-Blast 4160-Vac circuit breakers to latch closed (also called "going trip-free"). Failures occurred during post-overhaul, preoperational, and in-service surveillance testing. At Maine Yankee, failures occurred shortly after an overhaul of the breakers, during troubleshooting of an indirectly related problem with limit switches. The affected breakers have failed to latch on a random basis during up to about two-thirds of attempted closures, both electrically and manually. At both plants, the affected breakers were among those recently overhauled by the GE Apparatus Service Division of Philadelphia, with quality assurance coverage provided by GE Nuclear Energy (NE) Power Delivery Services (PDS) of King of Prussia, Pennsylvania. Failure analysis, inspection, and testing of one of the affected breakers from Maine Yankee were performed at the GE Apparatus Service Division under the direction of GE NE PDS and the design engineer from the breaker manufacturer, GE Specialty Breaker Plant. The results were consistent with onsite testing at both Millstone and Maine Yankee. The failure analysis activities, observed by NRC and licensee representatives, identified the primary failure mode, apparent principal root causes, and the most effective remedies.

Discussion

The breaker models considered to be potentially affected at the present time include (1) Type AM-4.16-350-1H and (2) Type AM-4.16-250-6, -7, -8, or -9HB. GE is currently evaluating other Magne-Blast models for potential susceptibility. Among these models, only breakers equipped with one prop reset spring (prop spring), and in which all "Tuf-Loc" (Teflon-coated fiberglass) bushings (especially the prop bushings) have been replaced with aluminum-bronze bushings, have recently experienced unreliable latching. However, it should be noted that this failure ultimately results from a combination of contributing factors and not all breakers of the potentially affected type and configuration are prone to failure. In addition, there have been a few instances (although not recently) of one-prop spring breakers with Tuf-Loc prop bushings that have failed to latch due to other unsatisfactory conditions within the breaker such as excessive wear, hardened or insufficient lubrication, and/or being severely out of adjustment. No failures are known to GE or the NRC to occur in breakers equipped with two prop springs (included as original equipment since 1968, or added during maintenance or repair). The failure analysis testing appeared to confirm the GE position that breakers with two prop springs should not experience this problem. The details of the failure mode are discussed in Attachment 1 to this information notice. Attachment 2 shows the prop springs.

It should be noted that, depending on the severity of the various contributing conditions, the onset of failure to latch reliably in these breakers may vary, and a breaker that has successfully passed rigorous post-maintenance testing and further receipt inspection and preoperational testing may subsequently start failing to latch reliably in service. In recent instances, failures to latch have begun to occur after about 35-50 operations (cycles) following overhaul or repair of the operating mechanism. Once started, the failure frequency has been observed during testing, to vary from 1 failure to latch in as many as 50 consecutive operations to 16 failures in 24 attempts. The operating characteristics of a given breaker (in particular, adequacy and consistency of prop action as explained in Attachment 1) can indicate the likelihood of unreliable latching. According to GE, the desired prop action positions the prop fully forward against its stop, thus providing maximum engagement under the prop pin (called prop wipe). However, affected breakers that start (or are likely to start) failing to latch reliably typically exhibit inconsistent (and often less than the design minimum) prop wipe even when they do latch.

The NRC and licensees have expressed concerns regarding increased susceptibility to unwanted tripping with less than minimum design prop wipe caused by vibration or shock (e.g., during a seismic event). The Magne-Blast design engineer has stated that because of the geometry and magnitude of forces acting on the prop, once the mechanism has successfully latched (even if only barely), it would be extremely unlikely for the shocks or vibration associated with seismic events to cause the prop to move backwards and out from under the prop pin. Nevertheless, a breaker that is latched, but with less than the design minimum prop wipe, is not in a condition for which it was analyzed or in which it was tested during seismic qualification.

Normal prop wipe can be confirmed with the breaker in its cubicle and closed (in test position if necessary) in most installations by visual inspection (using an inspection mirror and light) without having to get too close to energized components or hazardous mechanism parts if the switchgear cabinet door can be opened with appropriate safety precautions. Pending issuance of a service advice letter (SAL) by the manufacturer on this problem or a safety communication by GE NE, Attachment 2 illustrates an inspection hole in the right side of the mechanism frame through which the prop and prop pin position may be viewed. While the fully forward prop position (to the stop) is the desired condition (maximum wipe), the absence of failures to latch along with consistent and greater than minimum allowed prop wipe is, according to GE, indicative of continued reliable latching. However, because minimum prop wipe is not a published design specification, and because certain other factors (e.g., opening spring adjustment) may influence latching reliability, GE has requested that any licensee experiencing Magne-Blast breaker latching problems or noticing changed, inconsistent or apparently abnormally low prop wipe, particularly following overhaul or repair including prop bushing replacement, contact GE NE PDS at (610) 992-6049.

Pending installation of a second prop spring in affected breakers, Maine Yankee has shifted, to the extent possible, its available dual prop spring breakers to locations where operability requires assured latching reliability for closure or reclosure during a design-basis event. For the remaining potentially affected breakers, Maine Yankee is planning expedited inspections with the assistance of GE NE PDS to aid in its operability determinations.

Related Generic Communications

Information Notice 84-29, "General Electric Magne-Blast Circuit Breaker Problems," dated April 29, 1984.

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

Information Notice 93-91, "Misadjustment Between General Electric 4.16-KV Circuit Breakers and Their Associated Cubicles," dated December 3, 1993.

Information Notice 94-02, "Inoperability of General Electric Magne-Blast Breaker Because of Misalignment of Close-Latch Spring," dated January 7, 1994.

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.

CIGrimes for

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

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

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(301) 504-2980

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Attachments:
1. Details of Failure Mode and Contributing Factors
2. Magne-Blast Prop Mechanism Diagram
3. List of Recently Issued NRC Information Notices

Enclosure Filed in Jacket

DETAILS OF THE FAILURE MODE AND CONTRIBUTING FACTORS

The cause of the failures to latch cited in the body of the Information Notice is related to a component of the Type ML-13 breaker operating mechanism called the prop (see Attachment 2). The breaker will fail to latch closed when the prop does not travel forward fast enough (relative to the motion of the closing linkage) to be in the proper position under the prop pin of the closing linkage as it rises above then descends onto the prop during the closing cycle (whether manually or electrically initiated). Absent a trip condition upon closing, the prop is permitted (by the rotation of the main cam) to be pulled forward under the prop pin by the prop reset spring (or springs when two are fitted). If the slower speed of the prop relative to the pin is such that the pin passes down in front of the prop instead of landing on top of it (called latching) as it is supposed to, the linkage will "collapse" causing the moving contact arms to immediately drop down to the open position. This condition or action is also called the trip-free condition because it occurs in the same manner as if a trip signal were present at the breaker tripping mechanism when the breaker attempts to close, thus preventing the prop from moving forward and latching.

According to GE, and as apparently confirmed by testing, several conditions must be present to render a given breaker susceptible to this failure mode. Most fundamental are the individual breaker model and configuration, mechanism type, and vintage. Within these constraints, certain modifications or upgrades that have (or have not) been performed on a given breaker influence its susceptibility. Finally, the condition of the breaker mechanism in terms of age and type of moving parts, wear, lubrication, and adjustment can ultimately be the determining factor with regard to latching reliability.

Due to their particular combination of operating (opening and closing) spring configurations, all 4.16-kilovolt (Kv)-rated, vertical-lift, air-magnetic (Magne-Blast) breakers of 350-million volt-ampere (MVA) interrupting rating (Type AM-4.16-350-1H) that are fitted with only one prop spring are considered by GE to be potentially affected. Also potentially affected, owing also to their particular operating spring configurations, are those 4.16-Kv, 250-MVA-rated Magne-Blast breakers with one prop spring that have a 78-kilo-ampere (kA) close-latch rating (called a "high momentary" rating), which includes Models AM-4.16-250-6, -7, -8, or -9HB (the "H" suffix indicates the ML-13 type mechanism and the "B" indicates the high momentary rating).

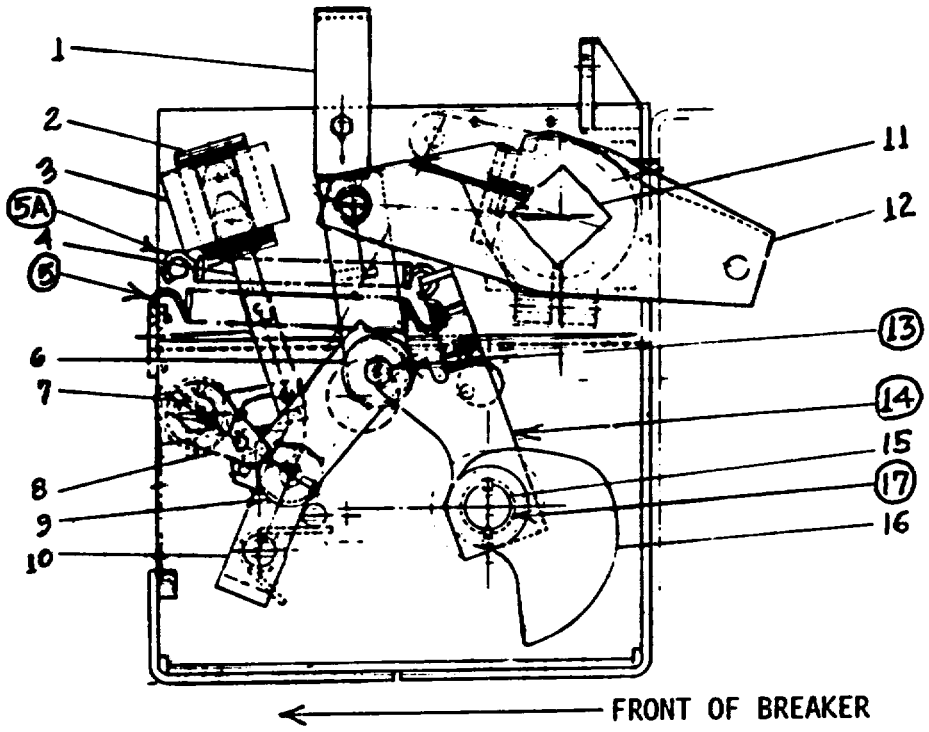
Within this population, the major factor determining susceptibility is the number of prop springs installed. With one anomalous exception (a breaker suspected of being grossly out of adjustment), only breakers with one prop spring have thus far been reported to experience unreliable latching. Breakers of these models built before about 1968 were originally fitted at the factory with a single prop spring. After this time, breakers with close and latch ratings of 77 Ka or 78 Ka were factory fitted with two prop springs, in order, according to GE, to make the breakers less sensitive to fit and adjustment tolerances and to facilitate factory setup. The failure analysis testing indicated that breakers built with or modified subsequently to add a second (upper) prop spring, and that are not otherwise in severely out of tolerance condition, should not be susceptible to this failure mode.

The breaker manufacturer, in GE Service Advice Letter (SAL) No. 073-348.1, issued in December 1990, recommended replacement of the main (lower) prop spring with an improved spring (called the "gold" prop spring because of the color of its cadmium plating). NRC Information Notice 90-41, "Potential Failure of General Electric Magne-Blast Circuit Breakers and AK Circuit Breakers," also addressed this problem. The gold prop spring has been fitted in breakers built since 1971, due to fatigue failures reported in the original spring. Although SAL 073-348.1 did describe the dual prop spring configuration, it did not address the addition of a second prop spring. See Attachment 2.

Recent breaker overhauls/repairs that included replacement of the Tuf-Loc (Teflon-coated fiberglass) prop bushings with aluminum-bronze prop bushings, in conjunction with cleaning and relubrication of the closing linkage and renewal of worn parts have not been demonstrated conclusively to be the sole cause of the recently reported failures to latch. However, they appear to have been the common precipitating events. In breakers of the affected models with one prop spring that have had all the Tuf-Loc bushings (except for the prop bushings) replaced with aluminum-bronze, the recently reported failures to latch have begun to occur after about 35-50 operations (cycles) after completion of overhaul or repair that included replacement of the Tuf-Loc prop bushings with aluminum-bronze. Since 1975, these breakers have been fitted with aluminum-bronze sleeve bearings or bushings in their mechanisms (except for the prop bushings) for improved wear characteristics. Many of the older Magne-Blast breakers, in accordance with GE SAL 073-318.1 (and .1A), issued in 1977, and 318.2, issued in 1979, have had their original Tuf-Loc bushings replaced with the aluminum-bronze bushings. IE Information Notice 84-29, "GE Magne-Blast Circuit Breaker Problems," also addressed this issue. The factory bushing replacement kits, supplied under catalog no. 0156C9403G001, did not include replacement bushings for the prop. Hence, most prop bushing replacements have been performed only recently.

When other conditions in a breaker are conducive to marginal latching, it appears that the new bushings, in conjunction with reduced friction in the closing linkage from the overhaul, cleaning and new lubricant, may shift the force and speed balance in the mechanism. The shift can be sufficient to speed up the motion of the closing linkage and prop pin relative to the prop (which also may actually be slightly retarded) beyond design margins. Under these conditions, a single prop spring can no longer move the prop forward fast enough to latch reliably, or if it does latch, to ensure the desired prop wipe. Where the second prop spring has been installed in conjunction with the mechanism overhaul, failure to latch reliably in the manner described herein has not been reported, and according to GE, as confirmed by testing, would not be expected to occur. Disassembly and detailed inspection of the Maine Yankee breaker operating mechanism after testing revealed no additional significant factors contributing to the failures to latch experienced by the test breaker. Therefore, the test results appear to have confirmed the factors to which close-latch reliability is most sensitive.

MAGNE-BLAST OPERATING MECHANISM PROP DIAGRAMS



1. Handle
2. Trip Coil Support
3. Trip Coil
4. Trip Armature
5. **PROP SPRING**
5A. **SECOND PROP SPRING** (if fitted)
6. Cam Follower Roller
7. Trip Shaft
8. Trip Latch
9. Trip Latch Roller
10. Roller Support
11. Crank Shaft
12. Cranks
13. **PROP PIN**
14. **PROP**
15. Drive Shaft
16. Cam
17. **PROP BUSHING**

Figure 1 (Adapted From Figure 7 of GE Instruction Book GEI-88761)

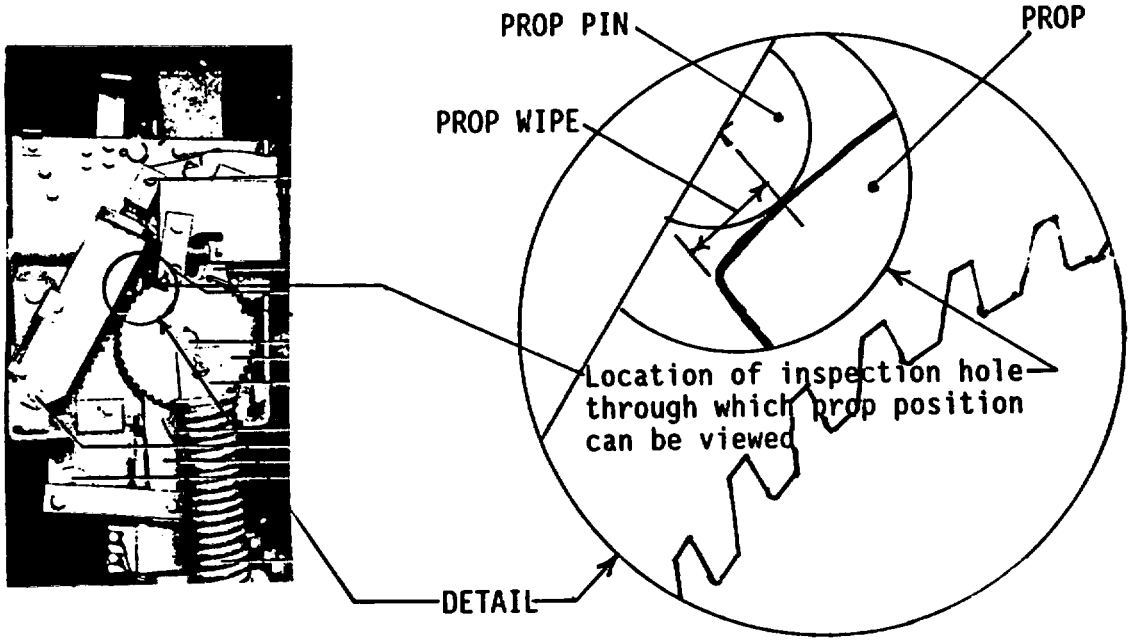


Figure 2: Right Side View of ML-13 Operating Mechanism
(From Figure 4 of GE Instruction Book GEI-88761)

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
91-45, Supp. 1	Possible Malfunction of Westinghouse ARD, BFD, and NBFD Relays, and A200 DC and DPC 250 Magnetic Contactors	07/29/94	All holders of OLs or CPs for nuclear power reactors.
94-42, Supp. 1	Cracking in the Lower Region of the Core Shroud in Boiling-Water Reactors	07/19/94	All holders of OLs or CPs for boiling water reactors (BWRs).
94-53	Hydrogen Gas Burn Inside Pressurizer During Welding	07/18/94	All holders of OLs or CPs for nuclear power reactors.
94-52	Inadvertent Containment Spray and Reactor Vessel Draindown at Millstone Unit 1	07/15/94	All holders of OLs or CPs for nuclear power reactors.
94-51	Inappropriate Greasing of Double Shielded Motor Bearings	07/15/94	All holders of OLs or CPs for nuclear power reactors.
94-50	Failure of General Electric Contactors to Pull in at the Required Voltage	07/14/94	All holders of OLs or CPs for nuclear power reactors.
94-49	Failure of Torque Switch Roll Pins	07/06/94	All holders of OLs or CPs for nuclear power reactors.
94-48	Snubber Lubricant Degradation in High-Temperature Environments	06/30/94	All holders of OLs or CPs for nuclear power reactors.
94-13, Supp. 1	Unanticipated and Unintended Movement of Fuel Assemblies and other Components due to Improper Operation of Refueling Equipment	06/28/94	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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orig /s/'d by CIGrimes/for

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*SEE PREVIOUS CONCURRENCE

VIB:DRIL	VIB:DRIL	SC/VIB:DRIL	TECHED
SAlexander*	KNaidu*	GCwalina*	MMejac*
05/19/94	04/14/94	05/19/94	04/18/94
C/VIB:DRIL:NRR	D/DRIL:NRR	EELB:DE:NRR	C/EELB:DE:NRR
LNorrholm*	CERossi*	SMitra*	CBerlinger*
05/24/94	05/27/94	07/06/94	07/11/94
OGCB:DORS:NRR	AC/OGCB:DORS:NRR	D/:DORS:NRR	
PWen*	ELDoolittle*	BKGrimes for	
07/13/94	07/14/94	07/27/94	

OFFICIAL RECORD COPY DOCUMENT NAME: 94-54.IN

NOTE: The PMs for Maine Yankee (E. Trottier) and Millstone-1 (J. Andersen) have been informed of the development of this information notice, and their comments have been incorporated.

Steve Alexander of the Vender Inspection Branch has consulted with GE on the technical accuracy of this information notice. GE's comments have been incorporated.

Peter Wen, 7/13/94

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05/19/94	04/14/94	05/19/94	04/18/94
C/VIB:DRIL:NRR	D/DRIL:NRR	EELB:DE:NRR	C/EELB:DE:NRR
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OGCB:DORS:NRR	AC/OGCB:DORS:NRR	D/:DORS:NRR	
PWen PCW	ELDoolittle	BKGrimes	
07/13/94	07/14/94	07/ /94	

OFFICIAL RECORD COPY DOCUMENT NAME: GEMAGNET.IN

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Normal prop wipe can be confirmed with the breaker in its cubicle and closed (in test position if necessary) in most installations by visual inspection (using an inspection mirror and light) without having to get too close to energized components or hazardous mechanism parts if the switchgear cabinet door can be opened with appropriate safety precautions. Pending issuance of a service advice letter (SAL) by the manufacturer on this problem or a safety communication by GE NE, Attachment 2 illustrates an inspection hole in the right side of the mechanism frame through which the prop and prop pin position may be viewed. While the fully forward prop position (to the stop) is the desired condition (maximum wipe), the absence of failures to latch along with consistent and greater than minimum allowed prop wipe is, according to GE, indicative of continued reliable latching. However, because minimum prop wipe is not a published design specification, and because certain other factors (e.g., opening spring adjustment) may influence latching reliability, GE has requested that any licensee experiencing Magne-Blast breaker latching problems or noticing changed, inconsistent or apparently abnormally low prop wipe, particularly following overhaul or repair including prop bushing replacement, contact GE NE PDS at 610-992-6049.

Pending installation of a second prop spring in affected breakers, Maine Yankee has shifted, to the extent possible, its available dual prop spring breakers to locations where operability requires assured latching reliability for closure or reclosure during a design-basis event. For the remaining potentially affected breakers, Maine Yankee is planning expedited inspections with the assistance of GE NE PDS to aid in its operability determinations. NRC Information Notice 94-XX, issued May XX, 1994, discusses other recently identified problems impacting Magne-Blast operability, related to defective and improperly installed GE CR2940 limit switches.

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.

ORIG /S/'D BY BKGRIMES
Brian K. Grimes, Director
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Technical contacts: Stephen Alexander, NRR (301) 504-2995
Kamalakar Naidu, NRR (301) 504-2980
Sikindra Mitra, NRR (301) 504-2783

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2. Magne-Blast Prop Mechanism Diagram
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*See previous concurrence

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OFFICIAL RECORD COPY DOCUMENT NAME: MAGNE3AT.GE

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Pending installation of a second prop spring in affected breakers, Maine Yankee has shifted to the extent possible, its available dual prop spring breakers to locations where operability requires assured latching reliability for closure or reclosure during a design-basis event. For the remaining potentially affected breakers, Maine Yankee is planning expedited inspections with the assistance of GE NE PDS to aid in its operability determinations. NRC Information Notice 94-XX, issued May XX, 1994, discusses other recently identified problems impacting Magne-Blast operability, related to defective and improperly installed GE CR2940 limit switches.

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05/ /94	05/ /94	05/ /94	05/ /94
OGCB:DORS:NRR	AC/OGCB:DORS:NRR	D/:DORS:NRR	
PWen	AJKugler	BKGrimes	
05/ /94	05/ /94	05/ /94	

OFFICIAL RECORD COPY DOCUMENT NAME: MAGNE3AT.GE

*See previous concurrence.

Prop wipe can be determined in most installations by visual inspection without having to get too close to hazardous mechanism parts if the switchgear cabinet door can be opened safely. Pending issuance of a SAL by the manufacturer on this problem (and/or a Service Information Letter by GE NE), Attachment 2 illustrates one location where the prop position may be seen. While fully forward prop position (to the stop) is the desired condition (maximum wipe), the absence of failures to latch along with consistent and greater than minimum allowed prop wipe is, according to GE, indicative of continued reliable latching. However, because minimum prop wipe is not a published design specification, and because certain other factors (e.g. opening spring adjustment) may influence latching reliability, GE has requested that any licensee experiencing Magne-Blast breaker latching problems or noticing changed, inconsistent or what appears to be abnormally low prop wipe, particularly following prop bushing replacement, contact GE NE PDS at 215-992-6049.

In the meantime, pending installation of a second prop spring in its affected breakers, Maine Yankee has shifted to the extent possible, its available dual prop spring breakers to locations where operability requires assured latching reliability for closure or reclosure during a design basis event. For the remaining suspect breakers, Maine Yankee has undertaken expedited inspections with the assistance of GE NE PDS to aid in its operability determinations. NRC Information Notice 94-XX, issued April XX, 1994, discusses other recently identified problems impacting Magne-Blast operability, related to defective and improperly installed GE CR2940 limit switches.

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ORIG /S/'D BY BKGRIMES
Brian K. Grimes, Director
Division of Operating Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: Stephen Alexander, NRR
(301) 504-2995
Kamalakar Naidu, NRR
(301) 504-2980

Attachments:
1. Details of Failure Mode and Contributing Factors
2. Magne-Blast Prop Mechanism Diagram
3. List of Recently Issued NRC Information Notices

VIB:DRIL	VIB:DRIL	SC/VIB:DRIL	TECHED
Salexander	Knaidu	Gcwalina	M.MEJAC
04/ /94	04/ /94	04/ /94	04/18/94
C/VIB:DRIL:NRR	D/DRIL:NRR	EELB:DE:NRR	C/EELB:DE:NRR
Lnorrholm	CERossi	SMitra	Cberlinger
04/ /94	04/ /94	04/ /94	04/ /94
OGCB:DORS:NRR	AC/OGCB:DORS:NRR	D/:DORS:NRR	
PWen	AJKugler	BKGrimes	
04/ /94	04/ /94	04/ /94	

OFFICIAL RECORD COPY DOCUMENT NAME: MAGNBLST.IN

Prop wipe can be determined in most installations by visual inspection without having to get too close to hazardous mechanism parts if the switchgear cabinet door can be opened safely. Pending issuance of a SAL by the manufacturer on this problem (and/or a Service Information Letter by GE NE), Attachment 2 illustrates one location where the prop position may be seen. While fully forward prop position (to the stop) is the desired condition (maximum wipe), the absence of failures to latch along with consistent and greater than minimum allowed prop wipe is, according to GE, indicative of continued reliable latching. However, because minimum prop wipe is not a published design specification, and because certain other factors (e.g. opening spring adjustment) may influence latching reliability, GE has requested that any licensee experiencing Magne-Blast breaker latching problems or noticing changed, inconsistent or what appears to be abnormally low prop wipe, particularly following prop bushing replacement, contact GE NE PDS at 215-992-6049.

In the meantime, pending installation of a second prop spring in its affected breakers, Maine Yankee has shifted to the extent possible, its available dual prop spring breakers to locations where operability requires assured latching reliability for closure or reclosure during a design basis event. For the remaining suspect breakers, Maine Yankee has undertaken expedited inspections with the assistance of GE NE PDS to aid in its operability determinations. NRC Information Notice 94-XX, issued April XX, 1994, discusses other recently identified problems impacting Magne-Blast operability, related to defective and improperly installed GE CR2940 limit switches.

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VIB:DRIL	VIB:DRIL	SC/VIB:DRIL	TECHED
Salexander	Knaidu HAS CONCURRED VERBALLY KEN	Gcwalina	
04/15/94	04/14/94	04/ /94	04/ /94
C/VIB:DRIL:NRR	D/DRIL:NRR	EELB:DE:NRR	C/EELB:DE:NRR
Lnorrholm	CERossi	SMitra	Cberlinger
04/ /94	04/ /94	04/ /94	04/ /94
OGCB:DORS:NRR	AC/OGCB:DORS:NRR	D/:DORS:NRR	
PWen	AJKugler	BKGrimes	
04/ /94	04/ /94	04/ /94	

OFFICIAL RECORD COPY DOCUMENT NAME: MAGNBLST.IN