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AEP
INDIANA
MICHIGAN
POWER

November 29, 1999

United States Nuclear Regulatory Commission
Document Control Desk
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Operating License DPR-58
Docket No. 50-315

Document Control Manager:

In accordance with the criteria established by 10 CFR 50.73 entitled Licensee Event Report System, the following interim report is being submitted:

LER 315/99-027-00, "Underrated Fuses Used in 250 VDC System Could Result in Lack of Protective Coordination."

No new commitments were identified in this submittal.

Sincerely,

M. W. Rencheck
Vice President – Nuclear Engineering

/ssn
Attachment

c: J. E. Dyer, Region III
R. C. Godley
D. Hahn
W. J. Kropp
R. P. Powers
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NRC Resident Inspector
Records Center, INPO

IE22

PDR ADOCK 05000315

NRC Form 366 (6-1998) U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

APPROVED BY OMB NO. 3150-0104 EXPIRES 06/30/2001

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS MANDATORY INFORMATION COLLECTION REQUEST: 50.0 HRS. REPORTED LESSONS LEARNED ARE INCORPORATED INTO THE LICENSING PROCESS AND FED BACK TO INDUSTRY. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (T-6 F33), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503

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TITLE (4)

Underrated Fuses Used in 250 VDC System Could Result in Lack of Protective Coordination

EVENT DATE (5)			LER NUMBER (6)					REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER			REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
											DC Cook - Unit 2	50-316
10	27	1999	1999	--	27	--	00	11	29	1999	FACILITY NAME	DOCKET NUMBER

OPERATING MODE (9)	-	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)							
POWER LEVEL (10)	00		20.2201 (b)		20.2203(a)(2)(v)		50.73(a)(2)(i)		50.73(a)(2)(viii)
			20.2203(a)(1)		20.2203(a)(3)(i)	X	50.73(a)(2)(ii)		50.73(a)(2)(x)
			20.2203(a)(2)(i)		20.2203(a)(3)(ii)		50.73(a)(2)(iii)		73.71
			20.2203(a)(2)(ii)		20.2203(a)(4)		50.73(a)(2)(iv)		OTHER
			20.2203(a)(2)(iii)		50.36(c)(1)		50.73(a)(2)(v)		Specify in Abstract below or n NRC Form 366A
			20.2203(a)(2)(iv)		50.36(c)(2)		50.73(a)(2)(vii)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
M. B. Depuydt, Regulatory Compliance	616/465-5901, x1589

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX

SUPPLEMENTAL REPORT EXPECTED (14)			EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
	YES (If Yes, complete EXPECTED SUBMISSION DATE).	X NO				

Abstract (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On October 27, 1999, with both units defueled, it was determined that fuses rated only for 250 VAC service were installed in various DC circuit applications without adequate supporting analysis, which could challenge the ability of the DC system to respond to overload conditions and to effectively accommodate the initiating event and a single electrical failure. This condition was initially determined to represent an unanalyzed condition due to a potential for redundant safety equipment to be rendered inoperable by a single active failure, and a 4-hour non-emergency ENS notification was made pursuant to 10CFR50.72(b)(2)(i). Upon further review, it was determined that faults would be cleared without collateral damage to surrounding safety related components, and this issue was more appropriately characterized as a condition which could compromise the protective coordination scheme of the 250 VDC system. As such, this LER is submitted in accordance with 10CFR50.73(a)(2)(ii) for a condition outside the design basis.

The cause of this condition is the failure to perform an adequate review of applicable industry experience and vendor supplied information, and to fully understand the design basis of the system. Corrective actions will include replacement of the affected fuses as appropriate. Actions to prevent recurrence relative to the operating experience and design basis have been previously addressed in AEP:NRC:1260GH.

Based on our review, it was concluded that faults due to an accident initiating event would be cleared without collateral damage to surrounding safety related components. Postulated impact is restricted to partial loss of the DC safety trains. Based on the results of previous testing conducted by both the fuse manufacturer and DC Cook, and the lack of recorded instances at the plant where the protective coordination failed to function as designed, it is concluded that this condition had minimal safety significance and did not jeopardize the health of safety of the public.

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TEXT *(If more space is required, use additional copies of NRC Form (366A)* **(17)**

Conditions Prior to Event
Unit 1 was defueled
Unit 2 was defueled

Description of Event
During the Expanded System Readiness Review (ESRR) an evaluation of the 250 VDC protective devices was conducted. At that time, weaknesses were identified in the use of 250 VAC fuses in safety-related applications. Specifically, the 250 VDC system was found to contain fuses rated below the 250 VDC nominal system voltage. These fuses may not provide adequate fault protection at the voltage levels encountered in the system.

Protection in the 250 VDC system is afforded primarily by Gould Type TR and Bussman Type FRN fuses. Gould TR-R fuses have a DC voltage rating of only 160 VDC. The 250 VDC system has an equalizing voltage of approximately 277 VDC and operates at a float voltage of approximately 260 VDC. Gould has stated that it is their belief that the fuses will not operate safely at voltages above their DC service rating of 160 VDC. Bussman FRN fuses have passed similar DC application tests at a maximum voltage of 125 VDC. And, similar to Gould, Bussman has not provided assurance of safe operation beyond this service rating.

As a result of the concern which arose during the ESRR, laboratory testing was conducted on a wide range of Gould TR type fuses at 280 VDC in accordance with UL Standards 248-1 and 198L. Lab results indicate that fuse casing sizes of 100, 200, 400, and 600 amps met all acceptance criteria. Fuse casing sizes of 30 and 60 amps failed to meet all applicable criteria. The conclusion was that the Gould TR fuses in fuse casing sizes of 30 and 60 amps do not perform satisfactorily at 280 VDC. Some of these fuses failed in such a manner that adjacent components could also be affected, which is considered to be a worst case lab condition. In addition, an extended time delay was experienced prior to the fuse eventually clearing the faulted condition. This lab result would cause DC coordination under such conditions to be considered indeterminate.

Cause of Event
This condition was attributed to lack of proper evaluation and consideration of available industry operating experience regarding fuse applications, and weaknesses in the understanding of the design and licensing basis of the 250 VDC system.

When the plant was originally designed, DC voltage ratings for fuses were not considered because there were no industry standards for DC voltage ratings at that time. Fuses were selected based on the AC voltage rating and the current limiting or non-current limiting (as desired) characteristics of the fuse. The fuses that were originally installed were Bussman REN fuses, which were already in use in DC circuits in the industry. The REN fuses were selected because of high reliability and low susceptibility to vibration and aging, but they were non-current limiting fuses. These fuses were replaced in the late 1970s – early 1980s time frame with Bussman FRN and Gould-Shawmut TR fuses. These fuses were selected because of their current limiting characteristic. However, at the time of replacement, industry standards addressing the DC voltage rating of the fuses had still not yet become available.

In 1981 Bussman Type FRN-R and Gould Shawmut Type TR-R Class RK5 fuses were analyzed by the manufacturers and Underwriter Laboratories (UL) to predict their response to DC system faults. The results led to a derating of the DC voltage rating of the fuses since the fuses did interrupt the current, but some damage to the fuse occurred. Since UL requirements stipulate that no damage to the fuse is acceptable, Gould Shawmut revised their specification sheets to reflect a 200 VDC voltage rating.

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TEXT *(If more space is required, use additional copies of NRC Form (366A)* **(17)**

Information became available via NRC Information Notice (IN) 84-65, which discussed the DC ratings being developed for AC rated fuses as discussed in UL Standard UL 198L. In response to NRC IN 84-65, DC Cook developed an analysis demonstrating a lower inductance and stored energy at interruption in the 250 VDC system than was used in the test. This analysis concluded that this condition would allow the fuse to clear a postulated fault and justified the continued use of the installed fuses.

Sufficient industry operating experience existed by the early 1990s to suggest that fuse replacements were appropriate, however, fuse replacement was not implemented at that time.

In addition, a lack of understanding of the design basis was demonstrated in that the analysis that was performed to justify the use of 250 VAC fuses did not consider the float and equalizing voltage for the system of 262 VDC and 277 VDC respectively. The analysis also did not consider overload conditions, i.e. 200% of fuse rating.

Analysis of Event

On October 27, 1999, it was determined that an unanalyzed condition existed due to a potential for redundant safety equipment to be rendered inoperable by the initiating event and a single active failure, and an ENS notification was made in accordance with 10CFR50.72(b)(2)(i) for an unanalyzed condition. Based on subsequent evaluation, it was determined that this issue was more appropriately characterized as a condition which compromised the protective coordination scheme of the 250 VDC system. Therefore, this LER is submitted in accordance with 10CFR50.73(a)(2)(ii) for a condition outside the design basis.

The 250V DC system provides a reliable source of continuous power at 250V DC for operation and control of plant safety-related systems. Included in the safety systems are the reactor trip system, engineered safety features and auxiliary support features. Each unit has two independent and redundant main 250V DC trains that supply power for a duplicated set of engineered safety systems. The 250V DC system also provides a continuous 250V DC power supply to non-safety related loads required for coping with Station Black Out (SBO) and Appendix R events, and to other non-safety related loads.

When installed in Class 1E equipment, a fuse must carry the design basis load current without interruption. Spurious interruption of the current would adversely affect the function of any safety related equipment downstream of the fuse. In the event of an actual load fault or overload condition, the fuse is required to open to prevent degradation of the associated 1E distribution system.

When a fuse is required to interrupt a fault at a voltage above its design rating, the fuse is not likely to perform in accordance with its published time current characteristic. This typically results in a longer interruption time for a given fault current due to re-striking. Performance to the published time response curve is a critical element in ensuring the coordination of the various protective devices. Failure to perform at the published curve values could result in slower responses, challenging upstream protective devices and resulting in de-energization of additional safety equipment. Since protection from electrical faults is a principal design feature of the 250 VDC system, the condition of indeterminate coordination challenges this primary aspect of the design.

Of additional concern is the potential for collateral damage to adjacent circuits or personnel in cases where the underrated fuse fails to interrupt the faulted circuit and experiences a loss of case integrity. Historically, D.C. Cook operating experience has not indicated failures of the type described above. Review of past job order history indicates that 250 VDC fuses have blown, but have not resulted in failure of the fuse casing. This is attributed to several factors. First, the current rise time (system time constant) of the plant system is somewhat shorter than the value used in the UL testing. This is primarily due to the resistive nature of the connected loads. Second, the UL testing was performed at a value of 280 VDC that exceeds the in-service voltage value. The nominal operating voltage is in the range of 260 VDC at the station battery

when the battery charger is in service. This condition, combined with additional voltage drops through the distribution system improves the ability of the fuse to clear a fault.

The orientation of the individual fuses and the required separation between the "A" and "B" trains provides reasonable assurance that a single failure will at most impact the associated battery system. This is further supported by the fact that the DC system is ungrounded, with each polarity individually fused. Therefore, either a component internal short or multiple cable paths to ground are required to cause a faulted condition. A single ground path will result in annunciation in the control room alerting operations personnel.

Testing was conducted on three separate occasions to evaluate performance of the Gould Shawmut TR-R fuses in 250 VDC systems. The results of these tests reflect various system operating conditions. Two of the tests were performed by the fuse manufacturer with differing results due to test parameters. The third test was performed independently by AEP.

- In 1984 tests were performed by the manufacturer at 250 VDC and resulted in acceptable performance of the fuse, which included some minor casing and end cap damage. Further evaluation of the 1984 test results provided reasonable assurance that the fuses installed in 250 VDC applications at DC Cook would reliably perform. This was attributed to inherent differences between the inductance, stored energy and time constant of the test circuit compared to the DC Cook 250 VDC system. It was concluded that due to those differences the fuses would not be subject to the extreme fault clearing conditions required by the UL Standards.

- In 1995 DC Cook performed independent fuse testing at the John E. Dolan Engineering Laboratory. This testing was performed at battery open circuit voltage of approximately 245 VDC with various size fuses. The results of this testing indicated acceptable performance of the fuses.

- In October 1999, additional testing was performed by Gould Shawmut to evaluate the performance of the TR-R fuses at 280 VDC utilizing testing standard UL198L. The results of this testing indicated failures in the 30A and 60A casing size families.

During Design Basis Accident conditions with a loss of offsite power (LOOP), there will be significant loads imposed on the DC system that will act to reduce the operating voltage throughout the system. The magnitude of these loads is such that the voltage values at individual fuse locations is expected to be less than the open circuit voltage values used in the testing conducted prior to October 1999. Therefore, it is expected that the fuse(s) will adequately clear a fault during accident conditions.

For accident conditions with less loading on the DC system (i.e., no LOOP), the system design is such that the end use component is in a mild environment or that upstream protective devices will function properly for the expected DC system voltages. As such, it was concluded that the existing DC system design provides adequate assurance that any faults due to an accident initiating event, such as high energy line break, fire or seismic event, will be cleared without collateral damage to surrounding safety related components.

No specific information is available regarding the potential degradation of protective coordination due to use of the underrated fuses. The probability of such a scenario of the type that would result in coordination deficiencies in the 250 VDC system protective fuses has been evaluated as low. Based on the results of previous testing conducted by both the fuse manufacturer and DC Cook, and the lack of recorded instances at the plant where the protective coordination failed to function as designed, it is concluded that this condition had minimal safety significance and did not jeopardize the health or safety of the public.

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Corrective Actions

Immediate corrective actions included placement of restrictions on operation of the 250 VDC batteries in the higher voltage equalization mode, and notification of Operations personnel of the need for heightened awareness of vulnerability to DC system grounds. An Operability Determination was performed for the plant conditions of Cold Shutdown, Refueling and defueled, which concluded that the system was Operable with non-conforming items.

As an additional conservative measure, the affected population of 30A and 60A rated fuses in safety-related applications are being evaluated for replacement prior to unit restart, unless otherwise justified. Certain non-safety related fuses that are considered important to unit operation will also be considered in this replacement effort. Additional testing, that is more representative of the DC Cook 250 VDC system configuration may be conducted to determine the adequacy of the existing fuses.

Additional actions will include performance of a new coordination study prior to unit restart to allow proper selection of fuses.

AEP:NRC:1260GH, "Enforcement Actions 98-150, 98-151, 98-152 and 98-186 Reply to Notice Of Violation October 13, 1998", dated March 19, 1999, responded to identified programmatic weaknesses in plant Design and Licensing Basis, and the Operating Experience Program. Corrective actions relative to plant Design and Licensing basis are being implemented via the Engineering Leadership Plan. A stronger and more comprehensive Operating Experience program was implemented through the Regulatory Affairs Leadership Plan.

Previous Similar Events

315/99-017-00
315/99-019-00