REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR: 8806020125 DOC. DATE: 88/05/26 NOTARIZED: NO DOCKET #
FACIL: 50-270 Oconee Nuclear Station, Unit 2, Duke Power Co. 05000270

AUTH. NAME	AUTHOR AFFILIATION
NORTH, P. J.	Duke Power Co.
TUCKER, H. B.	Duke Power Co.
RECIP. NAME	RECIPIENT AFFILIATION

SUBJECT: LER 88-002-00: on 880426, capacitance across replacement power circuit breakers 26 & 27 inducing resonance condition in CT2 transformer circuit. Caused by design deficiency. Startup transformer CT2 declared inoperable. W/880526 ltr.

DISTRIBUTION CODE: IE22D COPIES RECEIVED: LTR 1 ENCL 1 SIZE: 12
TITLE: 50.73 Licensee Event Report (LER), Incident Rpt, etc.

NOTES: AEOD/Ornstein: 1cy. 05000270

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	PD2-3 LA	1	1	PD2-3 PD	1	1
	PASTIS, H	1	1			
INTERNAL:	ACRS MICHELSON	1	1	ACRS MOELLER	2	2
	AEOD/DOA	1	1	AEOD/DSP/NAS	1	1
	AEOD/DSP/ROAB	2	2	AEOD/DSP/TPAB	1	1
	ARM/DCTS/DAB	1	1	DEDRO	1	1
	NRR/DEST/ADS 7E	1	0	NRR/DEST/CEB 8H	1	1
	NRR/DEST/ESB 8D	1	1	NRR/DEST/ICSB 7	1	1
	NRR/DEST/MEB 9H	1	1	NRR/DEST/MTB 9H	1	1
	NRR/DEST/PSB 8D	1	1	NRR/DEST/RSB 8E	1	1
	NRR/DEST/SGB 8D	1	1	NRR/DLPQ/HFB 10	1	1
	NRR/DLPQ/QAB 10	1	1	NRR/DOEA/EAB 11	1	1
	NRR/DREP/RAB 10	1	1	NRR/DREP/RPB 10	2	2
	NRR/DRIS/SIB 9A	1	1	NUDOCS-ABSTRACT	1	1
	REG FILE 02	1	1	RES TELFORD, J	1	1
	RES/DE/EIB	1	1	RES/DRPS DEPY	1	1
	RGN2 FILE 01	1	1			
EXTERNAL:	EG&G WILLIAMS, S	4	4	FORD BLDG HOY, A	1	1
	H ST LOBBY WARD	1	1	LPDR	1	1
	NRC PDR	1	1	NSIC HARRIS, J	1	1
	NSIC MAYS, G	1	1			
NOTES:		1	1			

TOTAL NUMBER OF COPIES REQUIRED: LTTR 46 ENCL 45

DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

May 26, 1988

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Subject: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287
LER 270/88-02

Gentlemen:

Pursuant to 10CFR 50.73 Sections (a) (1) and (d), attached is Licensee Event Report (LER) 270/88-02 concerning the inoperability of a portion of Unit 2 Emergency Power Switching Logic due to a design deficiency in breaker replacement analysis. This report is submitted pursuant to 10CFR50.73(a)(2)(v)(D). This event is considered to be of no significance with respect to the health and safety of the public.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

PJN/329/jgc

Attachment

xc: Dr. J. Nelson Grace
Regional Administrator, Region II
U.S. Nuclear Regulatory Commission
101 Marietta St., NW, Suite 2900
Atlanta, Georgia 30323

Ms. Helen Pastis
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Mr. P.H. Skinner
NRC Resident Inspector
Oconee Nuclear Station

American Nuclear Insurers
c/o Dottie Sherman, ANI Library
The Exchange, Suite 245
270 Farmington Avenue
Farmington, CT 06032

INPO Records Center
Suite 1500
1100 Circle 75 Parkway
Atlanta, Georgia 30339

M&M Nuclear Consultants
1221 Avenue of the Americas
New York, NY 10020

IE22
1/1

bxc: P.M. Abraham
B.W. Bline
R.J. Brackett
K.S. Canady
R.M. Dulin
R.C. Futrell
E.M. Geddie
W.A. Haller
G.W. Hallman
C.L. Harlin
C.L. Hartzell
R.C. Henderson ONS
S.A. Holland
C.C. Jennings ONS
T.A. Ledford
H.R. Lowery ONS
M.D. McIntosh
J.J. Maher
T.E. Mooney
F.E. Owens
P.L. Stiles
QA Tech. Serv. Manager (EC 1258)
QA Tech. Serv. NRC Coor. (EC 1255)
N.A. Rutherford
P.F. Guill
M.A. Haghi
OS-815.04
(29)

NRC Form 366
(9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150–0104
EXPIRES: 8/31/85

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Oconee Nuclear Station, Unit 2	0 5 0 0 0 2 7 0	1 OF 1 0

TITLE (4)
Inoperability of a portion of Emergency Power Switching Logic due to a design deficiency

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 NAMES	DOCKET NUMBER(S)
0 4	2 6	8 8	8 8	0 0 2	0 0	0 5	2 6	8 8		0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9): N

POWER LEVEL (10): 1 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check one or more of the following)* (11)

☐ 20.402(b)	☐ 20.405(c)	☐ 50.73(a)(2)(iv)	☐ 73.71(b)
☐ 20.405(a)(1)(i)	☐ 50.36(c)(1)	X 50.73(a)(2)(v)	☐ 73.71(c)
☐ 20.405(a)(1)(ii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(vii)	☐ OTHER *(Specify in Abstract below and in Text, NRC Form 366A)*
☐ 20.405(a)(1)(iii)	☐ 50.73(a)(2)(i)	☐ 50.73(a)(2)(viii)(A)	
☐ 20.405(a)(1)(iv)	☐ 50.73(a)(2)(ii)	☐ 50.73(a)(2)(viii)(B)	
☐ 20.405(a)(1)(v)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER: AREA CODE	
Philip J. North, Licensing	7 0 4	3 7 3 - 7 4 5 6

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)

☐ YES *(If yes, complete EXPECTED SUBMISSION DATE)* X NO

EXPECTED SUBMISSION DATE (15): MONTH | DAY | YEAR

ABSTRACT *(Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines)* (16)

Oconee 230 kV switchyard Power Circuit Breakers (PCBs) 26 and 27 were recently replaced by new higher interrupting capability circuit breakers. Due to transformer noise during certain maintenance/test conditions, Duke suspected that the capacitance across the replacement PCBs #26 and 27, was inducing a resonance condition in CT2 transformer circuit.

On April 26, 1988 it was determined that the condition could also exist as a result of a transformer lockout. This would result in the Emergency Power Switching Logic (EPSL) system falsely sensing that the startup transformer is a viable source of power, thus preventing an automatic transfer to the standby power source in the event of a LOCA concurrent with a CT2 lockout condition. When this incident was discovered, Units 1 and 2 were at 100% power and Unit 3 was in cold shutdown.

The immediate corrective action was to declare startup transformer CT2 inoperable, align Unit 3 startup transformer (CT3) to Unit 2 and feed Unit 3 auxiliary loads from standby transformer CT5.

The root cause of this incident was determined to be a design deficiency since ferroresonance was not considered during breaker replacement design analysis.

IE22
1/1

Background

In 1986, a study was performed of Duke's System Planning Department's predicted available fault duty on Power Circuit Breakers (PCB) [EIIS:BRK] at all of Duke's switching stations [EIIS:FK]. Based on the results of the study, Duke identified a need to changeout the 230 kV PCBs at Oconee because of a predicted increase in the system available fault duty resulting from the addition of new generating plants. Based on the results of the study, a specification was developed for replacement PCBs on the basis that the PCB changeout would be a direct replacement for the existing PCBs. These PCBs were purchased from Cogenel-Alsthom, a French manufacturer of power equipment. Because the study identified a need for increased PCB interrupting capability, increased PCB capacitance was needed. The capacitance is needed to suppress the increased rate-of-rise of recovery voltage, thereby preventing restrike across the breaker contacts following fault interruption, and to equalize the voltage gradient across the PCB contacts during normal breaker operation. The line-to-line capacitance value used on the Cogenel breaker made it totally self-sufficient to interrupt its nameplate fault rating (a very conservative design). The PCBs being replaced have a smaller capacitor [EIIS:CAP] across their contacts because the fault interruption capability was much lower than that of the Cogenel breakers.

The change in the capacitance value across the contacts of the PCB was discussed with Cogenel, who indicated that this is a common application, and they had not experienced any problems at other locations where this capacitance value is applied. Also, the application was discussed with Duke's Transmission Engineering Group who concurred with the application. It was not anticipated that any in-plant relaying would be affected by this capacitance change.

Technical Specification 3.7.2.b concerns the operability of functional units of Emergency Power Switching Logic (EPSL).

SEQUENCE OF EVENTS

July 2, 1986

- Using input from system planning, a design study identified the need for switchyard PCB's with higher interrupting capability, due to the addition of new generating plants.

July 14, 1986

- Procurement specification for PCB replacement was issued.

April 17, 1987

- Higher capacitance values of new PCBs were discussed with Cogenel who indicated that this is a common application and they have not experienced any problems at other locations where these PCBs are used.

October 5, 1987

- Design package for replacement of PCBs 26 and 27 replacement was released to the station for implementation.

February 3, 1988

- Unit 2 outage started during which PCBs 26 and 27 were replaced by new breakers.

March 29, 1988

- While performing the Load Shed Test on Unit 2, a startup transformer [EIIS:XFMR] (CT2) lockout occurred.

April 1, 1988

- A test was performed on CT2 and PCBs 26 and 27 by Nuclear Production and Transmission Departments in which low level ferroresonance was identified as a possible cause of CT2 lockout.

- A test to verify no damage was caused to the transformer, was performed on transformer CT2.

April 6, 1988

- A meeting was held between Design Engineering, Transmission and Nuclear Production Personnel to evaluate the new PCB application as related to the startup transformer circuit.

  Additional testing on CT2 was requested to determine transformer voltages and noise level during various PCB and disconnect open/close configurations. Based on existing information a decision was made to open the appropriate disconnects when isolating startup transformers for test or maintenance. The need for a problem investigation report (PIR) was identified to investigate possible effects of the large capacitors on other circuits and other conditions of operations.

NRC Form 366A
(9-83)

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES. 8/31/85

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Oconee Nuclear Station, Unit 2	0 5 0 0 0 2 7 0	8 8	— 0 0 2	— 0 0	0 4 OF 1 0

TEXT (If more space is required, use additional NRC Form 366A's) (17)

April 7, 1988

- A test was performed to determine whether low level ferroresonance could exist in startup transformer CT1. Results indicated acceptable conditions existed on CT1.

April 8, 1988

- A problem investigation report was initiated to investigate possible effects of the large capacitors on other circuits and other conditions of operation associated with the low level ferroresonant condition. This PIR was issued to Design Engineering on April 12, 1988. A written resolution of the PIR was scheduled for May 10, 1988. Operability issues and appropriate operator guidance were addressed as a result of the April 6 meeting.

April 10, 1988

- End of Unit 2 outage. Unit 2, including new PCBs 26 and 27, was placed in service.

April 6 thru 26, 1988

- Studies to assess various nonprocedural resolutions of the maintenance/test condition, and to further verify whether any other maintenance/test/operational conditions were affected, were ongoing in Design Engineering while awaiting CT2 test results. During this period CT2 was unavailable for testing due to its alignment to Unit 2 auxiliary loads during unit startup. Further evaluation of the PIR was being conducted.

April 26, 1988.

0900 - During further review of the PIR, Design Engineering discovered that the condition would also exist as a result of a transformer differential lockout, and raised questions concerning the undervoltage monitors and requested the station to provide voltage measurements on CT2.

1100 - Voltage readings were provided to Design Engineering.

1600 - Design Engineering contacted the station to discuss findings.

1645 - CT2 was declared inoperable. This was reported to the NRC via the Emergency Notification System pursuant to 10CFR50.72.

2153 _ New Cogenel breakers PCB 17, 26, and 27 were opened along with their disconnects.

2332 _ Unit 3, which was in cold shutdown was removed from its startup source (CT3) and connected to the Central switchyard through Transformer CT5.

2332 _ CT2 was isolated by opening its associated disconnects and Unit 2 was aligned to transformer CT3 startup source.

April 27, 1988

1330 _ Additional information was provided to the NRC by telephone.

May 1, 1988

1330 _ New capacitors were installed on PCBs 26 and 27.

1800 _ Test of PCBs 26 and 27 was completed.

1900 _ CT2 was returned to service.

Description of Incident

On March 29, 1988 while performing the Load Shed Test on Oconee Unit 2, a startup transformer (CT2) lockout occurred when the switchyard breakers PCBs 26 and 27 were closed (see attached figure). An investigation suggested that the contact capacitance provided in the new Cogenel breakers, when coupled with the PT/230kV line/transformer impedances resulted in a low level ferroresonant condition in the circuit. This condition exists specifically when PCBs 26 and 27, which feed CT2, are open, the associated PCB and transformer line disconnects are closed and the transformer low side circuit breakers are open. It was identified at this time that this condition would only exist during maintenance/test.

On April 26, 1988 with Units 1 and 2 at 100% full power and Unit 3 in cold shutdown, Duke discovered that the condition also existed as a result of a transformer differential, and that under this condition, the voltage on the low side of startup transformer CT2 would be of sufficient magnitude to exceed the dropout setting of the EPSL voltage sensing relays. This would result in the EPSL system falsely sensing that the startup transformer was a viable source of power, and prevent an automatic transfer to the Standby Power Source (Transformer CT4). This condition would exist only:

1. During maintenance when the PCBs were open and the PCB and transformer line disconnects were closed. This condition normally would exist in the maintenance mode only during the short time required to manually open the line disconnect after the PCBs have been opened.

2. Following a transformer differential lockout:

   a. For a valid lockout condition if the transformer failure did not initiate a sustained fault path to ground.

   b. For a false lockout condition.

Hence, if Conditions 1 or 2 existed, and the Unit 2 auxiliary power system loads automatically transferred to the startup source, the EPSL system would not automatically complete the action necessary to transfer the loads to the Keowee [EIIS:EK] underground source (CT4). Thus a condition that alone could have prevented the fulfillment of the safety function of a system that is needed to mitigate the consequences of an accident existed. Therefore, this incident is reportable pursuant to 10CFR50.73(a)(2)(v)(D).

During the low probability condition where a Unit 2 LOCA would occur at the same time that the Unit 2 startup transformer was in the condition as described in Conditions 1 or 2 above, operator action to restore power in the required time period could not be assumed. For other scenarios, the operator should have time to manually restore power in the required time period by following the loss of electric power abnormal procedure.

Cause of Occurrence:

The root cause of this incident was determined to be a design deficiency. Because of the higher interrupting capability of the new PCBs, higher PCB capacitance was needed. The high capacitance rating was a major contributing factor to the low level ferroresonant condition and the subsequent voltage level on the startup transformer secondary. This capacitance, when coupled with the linear and nonlinear electrical impedance characteristics of the startup transformer, can induce a low level ferroresonant condition in the transformer under unique conditions. The potential for unacceptable voltage levels on the plant auxiliary power system due to the use of higher PCB contact capacitance rating was not anticipated during the design phase. This was partially due to the fact that similar Cogenel PCBs are being used on other applications on the Duke system and the effect of the capacitance has resulted in acceptable bus voltages. Furthermore, no unique system conditions were addressed when the original ITE breakers were installed, nor do any of the breaker industry standards address the potential problem associated with breaker contact capacitance.

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Oconee Nuclear Station, Unit 2	0 5 0 0 0 2 7 0	8 8	— 0 0 2	— 0 0	0 7 OF 1 0

TEXT (If more space is required, use additional NRC Form 366A's) (17)

Additionally, due to the non-linear characteristics of the startup transformer impedance and the complexity of analytically modeling it, the accuracy of a calculation to anticipate the transformer low side voltage under a low level ferroresonant condition would have been unreliable. Ferroresonance of large power transformers as a result of PCB contact capacitance is very unusual in the industry. PCBs 17, 26 and 27 are the only breakers associated with startup transformers that had been replaced by the new breakers. This condition existed only in conjunction with the new PCBs, since the PCBs being replaced had a smaller capacitor across their contacts.

Since there were no equipment failures as a result of this incident, it is not NPRDS reportable.

CORRECTIVE ACTIONS

The immediate correction actions were to:

- o Declare the Unit 2 startup transformer (CT2) inoperable;
- o Align Unit 2 to the Unit 3 startup transformer (CT3);
- o Align Unit 3 to be fed from the Central switchyard through standby transformer (CT5) (Unit 3 was in cold shutdown);
- o Open PCB 17, which feeds the Unit 1 startup transformer (CT1), and its associated disconnects.

Subsequent corrective actions were to:

- o Perform an Integrated Design Review (IDR) meeting to review the design associated with capacitor changeout. It was decided in this meeting that another IDR(s) will be performed for the remainder of the switchyard PCB replacement modification;
- o Change capacitors on PCBs 26 and 27 to ones with lower capacitance. The circuit breakers were tested and it was verified by test that the new capacitance produced acceptable voltages on the low side of startup transformer CT2 and eliminated the low level ferroresonant condition;
- o Align Startup Transformer CT2 back to Unit 2;
- o Align Startup Transformer CT3 back to Unit 3.

Planned corrective actions are to:

- o Replace the capacitors of the new PCBs with ones with lower capacitance. Design Engineering will identify the PCBs requiring this change;

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Oconee Nuclear Station, Unit 2	0 5 0 0 0 2 7 0	8 8	0 0 2	0 0	0 8 OF 1 0

TEXT (If more space is required, use additional NRC Form 366A's) (17)

- o Test PCBs affected by the capacitor changeout to verify the elimination of ferroresonance and/or other problems associated with the capacitance rating;

- o Perform a self-initiated technical audit on the Oconee Emergency Power System during the Fall of 1988;

- o Initiate a design study to review the Emergency Power Switching Logic (EPSL) System. Logic changes will be recommended to cover EPSL conditions associated with startup transformers lockout by November 30, 1988;

- o Make a reference to ferroresonance consideration in the Electrical Division Design Input Calculation NSM Engineering Checklist by November 30, 1988.

ANALYSIS OF OCCURRENCE:

The specific modes when a low level ferroresonant condition and the subsequent induced voltage on the startup transformer could exist are as follows:

1. During maintenance when the PCBs were open and the PCB and the transformer line disconnect switches were closed. This condition normally would exist in the maintenance mode only during the short time required to manually open the line disconnect after the PCBs had been opened as required by the Operating Department Methods and Procedure Manual Procedure.

2. Following a transformer differential lockout:

   a. For a valid lockout condition if the transformer failure did not initiate a sustained fault path to ground.

   b. For a false lockout condition.

The scenario of concern was a simultaneous Unit 2 LOCA and one of the events described in 1 or 2 above. Under a LOCA condition, the EPSL system would first seek auxiliary power from the Unit 2 startup source (Transformer CT2). However, due to the low level ferroresonance created by Conditions 1 or 2 above, the voltage induced on the low side of startup Transformer CT2 would be of sufficient magnitude to exceed the dropout setting of the emergency power switching logic voltage sensing relays. This would result in the emergency power switching logic system falsely sensing that the startup transformer was a viable source of power, thus preventing an automatic transfer to the standby power source (Transformer CT4).

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Oconee Nuclear Station, Unit 2	0 5 0 0 0 2 7 0	8 8	— 0 0 2 —	0 0	0 9 OF 1 0

TEXT (If more space is required, use additional NRC Form 366A's) (17)

The potential for Conditions 1 and 2, described above, to occur existed only in the short period of time from the date Unit 2 returned to service with new PCBs 26 and 27 until corrective actions were taken, i.e., April 10, 1988 to April 26, 1988.

During the low probability condition where the above scenario could have occurred, operator action to restore power in the required time period cannot be assumed. For other scenarios, it is expected that the operator would have time to manually restore power in the required time period by following the loss of electric power abnormal procedure.

At no time after the PCB replacement did the combination of conditions noted above occur; therefore, the health and safety of the public were not affected and no releases of radiation resulted from this incident.