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)
McGuire Nuclear Station, Unit 1	0 5 0 0 0 3 6 9	1 OF 0 8

TITLE (4) Reactor Trip/Turbine Trip Due To A Malfunction In The Excitation Switchgear Silicon Controlled Rectifier Firing Circuit

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 1	0 7	8 8	8 8	— 0 0 1 —	0 1	0 7	2 5	8 8		0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9): 1
POWER LEVEL (10): 0 7 4

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)	X 50.73(a)(2)(iv)	73.71(b)
20.405(a)(1)(i)	50.36(c)(1)	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
Steven E. LeRoy, Licensing	AREA CODE 7 0 4 3 7 3 - 6 2 3 3

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
X	E A	P S D	W 1 2 0	N					

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)

On 01/07/88 at approximately 0700, the Unit 1 Generator started to experience an abnormal voltage and reactive load transient. Operations attempted to combat the transient by manually adjusting the Excitation Switchgear output. The transient became too severe, and at 0708, the Generator and Turbine tripped because of a loss of excitation to the Generator field. The Turbine Trip caused a Reactor Trip. The abnormal voltage and reactive load transient was caused by a malfunctioning firing circuit in the Excitation Switchgear. This firing circuit controls the amount of excitation applied to the Generator to control voltage and reactive load. Unit 1 stabilized from the Reactor Trip by approximately 0740. The Transmission Department repaired the firing circuit portion of the Excitation Switchgear and Unit 1 was returned to power operation on 01/07/88 at 2253. This event is assigned a cause of Other because the transient/trip was caused by a malfunction in the Excitation Switchgear Silicon Controlled Rectifier (SCR) firing circuit. The failure mode of the phase shifter circuits will be evaluated and filtered cooling to the excitation switchgear will be reviewed.

IE22 1/1

INTRODUCTION:

On January 7, 1988 at approximately 0700, the Unit 1 Generator [EIIS:GEN] started to experience an abnormal voltage and reactive load transient. Operations (OPS) attempted to combat the transient by manually adjusting the Excitation [EIIS:EXC] Switchgear [EIIS:SWGR] output. The transient became too severe, and at 0708, the Generator and Turbine [EIIS:TRB] tripped because of a loss of excitation to the Generator field. The Turbine Trip caused a Reactor Trip. The abnormal voltage and reactive load transient was caused by a malfunctioning firing circuit in the Excitation Switchgear. This firing circuit controls the amount of excitation applied to the Generator to control voltage and reactive load.

Unit 1 stabilized from the Reactor [EIIS:RCT] Trip by approximately 0740. Transmission Department (GSS) personnel repaired the firing circuit portion of the Excitation Switchgear on January 7, 1988. Unit 1 was returned to power operation on January 7, 1988 at 2253.

Unit 1 was in Mode 1, Power Operation, at 74% power when the Reactor Trip occurred.

This event has been assigned a cause of Other because the transient/trip was caused by a malfunction in the Excitation Switchgear Silicon Controlled Rectifier [EIIS:RECT] (SCR) firing circuit [EIIS:PSD]. The exact cause of the malfunction in the firing circuit could not be determined during this investigation.

EVALUATION:

Background

The Excitation switchgear is a type WTA (Westinghouse Trinistat Amplifier [EIIS:AMP]) Voltage Regulator [EIIS:RG] - Brushless Excitation System manufactured by Westinghouse Electric Corporation. The Excitation Switchgear is powered from a shaft driven Permanent Magnet Generator (PMG) (see Page 8 of 8). The function of the Excitation Switchgear is to rectify and control excitation to a brushless Exciter. Rectification is accomplished by a SCR power unit, automatic control is accomplished by a voltage regulator, and manual control is accomplished by a base-adjust controller [EIIS:EC]. Control of the brushless exciter field current governs the output of the AC exciter which furnishes excitation to the field of the Generator through the shaft mounted rotating rectifiers.

The SCR power unit is supplied by Westinghouse and consists of two circuits: 1) The firing circuit; and, 2) The power amplifiers. The firing circuit accepts an analog DC signal from the base-adjust control or voltage regulator and generates pulses at various delay angles to fire the thyristors in the power amplifiers. The power amplifier uses these pulses to control the amount of current being supplied to the brushless Exciter field which governs the output of the AC Exciter. The phase shifter is a circuit within the firing circuits which is used to give a 90 degree phase lag to the firing pulses. There are two channels of firing circuits and each has a separate firing circuit for each of the 3 phases (X, Y, and Z) for a total of 6 firing circuits.

The amount of excitation to the field of the Generator controls the output voltage and reactive load [VARs (volts-amperes-reactive)]. The Generator normally operates at 24.00 KV and approximately 150 to 300 MVARs. When a synchronous generator loses excitation, it begins operating as an induction generator, and the rotor will quickly overheat from induced currents. A loss-of-excitation Protective Relay (Relay 40) [EIIS:RLY] is used to monitor the Generator output through current transformers [EIIS:XFMR] and will energize and operate Generator Lockout Relays 86GA and 86GB upon detecting a loss-of-excitation condition. When a signal is received from a protective relay, these lockout relays operate by means of a spring loaded handle that is unlatched and rotated one-eighth turn counterclockwise.

There is a set of contacts operated by this handle that will send signals to various other protective relays which will trip both Generator breakers, their motor operated disconnects, the Turbine, and the Exciter. A lockout relay must be reset manually before any of the equipment it tripped can be operated again. The Reactor will trip automatically whenever the Turbine trips above 48% power.

Description of Event

During the evening of December 31, 1987, the Unit 1 Generator began to experience a minor fluctuation in reactive load and voltage. Operations placed the voltage regulator in manual to control the reactive load and voltage with the base-adjust controller. The swing in reactive load and voltage stabilized. Operations notified GSS about the problem.

On January 2, 1988, GSS began to troubleshoot the Excitation Switchgear. With an oscilloscope [EIIS:OSC] connected to a test jack of the power amplifier output, GSS determined that 1 of the 6 firing circuits was intermittently firing a full output signal (approximately 30% higher output than the other 5 circuits). This meant that there was an intermittent excessively high output current going to the Exciter field, which in turn would cause a spike on Generator voltage and reactive load. The spike would last for a few seconds and occur intermittently on approximately 1 hour intervals. When the spike cleared, Generator voltage and reactive load would return to the value set by the base-adjust controller. GSS could not determine which of the six firing circuits was causing the excessive output signal. Since the spikes were of a manageable magnitude, Operations and GSS determined that they would continue to monitor the power amplifier output, and no further action by Operations was warranted at that point.

On January 6, 1988 at 0750, the Generator experienced a very high spike in reactive load from approximately 267 MVARS to approximately 611 MVARS. Operations reduced the reactive load by lowering Exciter output with the base-adjust controller. Generator voltage and reactive load continued to swing intermittently during the day, though not as severely as the earlier spike. GSS and Operations decided that troubleshooting must continue, but it would be prudent to reduce Generator load to approximately 900 MWe. At a reduced load, the Generator and Exciter would be better able to absorb spikes from the firing circuit. Operations began to reduce Generator load at 1820 on January 6, 1988, and stopped the load reduction at 1935 at 894 MWe. Operations and GSS had made arrangements with the

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

Duke Power System Load Dispatcher to continue troubleshooting after 0900 on January 7, 1988. Troubleshooting the Excitation Switchgear has the potential to cause a Generator Trip. After the load reduction, GSS did not observe any spikes from the firing circuit during the night of January 6, 1988.

On January 7, 1988 at approximately 0704, the Unit 1 Generator again began to experience a voltage and reactive load transient. At 0705:54, reactive load and voltage spiked excessively high at greater than 600 MVARS and 24.02 KV respectively. Operations began to reduce the Exciter output with the base-adjust controller to reduce Generator voltage and reactive load. They positioned the base-adjust controller at its minimum position. Generator voltage and reactive load began to drop rapidly. Operations then began to increase Exciter output with the base-adjust controller. At 0707:59, Generator voltage reached a low of 23.41 KV. At 0708:06.483, Generator Protective Relay 40 energized on a loss of excitation on the Generator. Relay 40 energized Lockout Relays 86GA and 86GB and tripped the Generator and Turbine. At 0708:06.736, the Reactor tripped because of a Turbine Trip with the Reactor greater than 48% power.

Operations implemented the Unit 1 Reactor Trip Recovery procedure. Main Feedwater [EIIS:SJ] isolation occurred at 0708:30 on a Reactor Trip with low T-ave signal. Both Main Feedwater pumps [EIIS:P] tripped on high discharge pressure, because of the Main Feedwater isolation, which caused an automatic start of the Auxiliary Feedwater motor [EIIS:MO] driven pumps to provide feedwater to the Steam Generators [EIIS:SG]. Approximately 30 minutes after the Reactor Trip occurred, at approximately 0740, Pressurizer [EIIS:PZR] pressure and level, Steam Generator level, and Reactor Coolant [EIIS:AB] T-ave reached no-load values.

After the Reactor Trip, GSS replaced the phase shifter in one channel and the entire firing circuit in the other channel. Unit 1 returned to Mode 1 on January 7, 1988 at 2253. When the Generator was put on line at 0021 on January 8, 1988, GSS checked the new firing circuit and phase shifters and found no problems.

Conclusion

The phase shifter circuit of the firing circuit cannot be tested satisfactorily with the Generator off line. GSS tested all other circuits of the firing circuit after the Reactor Trip and found no problems. GSS, after a discussion with Westinghouse, determined that the problem with the firing circuit was probably originating in the phase shifter circuits. GSS then decided to replace both phase shifter circuits. When the Generator was returned on line, GSS tested both firing circuits and could not find any problems. The firing circuit components that were removed have been sent to Westinghouse for further testing and evaluation.

GSS believes the equipment failure may have been caused by excessive heat in the Excitation Switchgear cabinet. This cabinet [EIIS:CAB] is located on the Turbine Floor in the Unit 1 Turbine Building. Temperatures at the cabinet have been measured at 95 degrees-F in December of 1987. The manufacturer suggests a maximum operating temperature of 113 degrees-F. Duke Power's Belews Creek fossil plant has the same equipment and has experienced many heat and dust related component failures. Belews Creek has consequently installed filtered cooling on the cabinet that has been effective in reducing the number and frequency of component failures.

This event has been assigned a cause of Other because the transient/trip was caused by a malfunction in the firing circuit phase shifter. It could not be determined during this investigation what caused the phase shifter circuit to malfunction.

There were a few anomalies noted during this Reactor Trip. Steam Generator Power Operated Relief Valves (PORVs) [EIIS:RV], 1SV-7 and 1SV-13, opened at 1110 PSIG and 1113 PSIG respectively, which is below the lower end of their open setpoint toleranc[illegible] PSIG. Performance wrote work requests to investigate and repair the ope[illegible]oints. Performance personnel believe that the setpoint range of ± 1% may be too restrictive for these valves and will review this setpoint range for a possible adjustment. Nuclear Instrumentation Source Range Channel N-31 failed in the high direction and IAE replaced a defective high voltage power supply to correct the problem. Nuclear Instrumentation Intermediate Range Channel N-35 responded too rapidly to the power decrease after the Reactor Trip. IAE determined that it was overcompensated and reset the compensating voltage to correct the problem. The Overpower and Overtemperature Delta T setpoints on Reactor Coolant (NC) system Loop D and Overpower Delta T on NC system Loop C did not respond as expected. IAE calibrated these setpoints and could not find any problems. They attributed the unexpected response to a lower amount of electronic noise in the NC system Loop C and NC system Loop D channels than in the other channels of Overpower and Overtemperature Delta T.

All primary and secondary system key parameters, with the exception of those noted above, responded as expected during this Reactor Trip. Operations responded to the transient in a timely and efficient manner to stabilize the unit. Approximately 30 minutes after the Reactor Trip, Pressurizer level and pressure, Steam Generator level and pressure, and NC system temperature had all achieved stable no-load conditions. The Auxiliary Feedwater system [EIIS:BA] started automatically and responded properly to provide feedwater to the Steam Generators. Main Feedwater isolation occurred on Reactor Trip with low NC system T-ave approximately 30 seconds after the Reactor Trip as expected.

A review of past McGuire Event Reports (LERs) revealed numerous Reactor Trips; however, there has been only one Reactor Trip in the last 3 years that was attributed to Excitation Switchgear problems. LER 370/85-27 reported a Reactor Trip caused by a misaligned fuse in the Excitation Switchgear. This event was attributed to a Management Deficiency that caused a lack of training on proper fuse installation. There were six other Reactor Trips in the last 3 years that were attributed to equipment malfunctions on other equipment. These were LERs 369/85-34, 370/85-17, 369/85-04, 369/86-07, 36[illegible]/86-02, and 369/87-04. Therefore, Reactor Trips caused by equipment malfunctions are considered to be recurring.

This event is not reportable to the Nuclear Plant Reliability Data System (NPRDS).

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CORRECTIVE ACTIONS:

Immediate: Operations implemented the Reactor Trip Recovery Procedure, AP/1/A/5500/01.

Subsequent:

1) GSS repaired the phase shifter circuits in both firing circuits of the Unit 1 Excitation Switchgear.

2) Performance has added Nuclear Instrumentation Source Range Channel N-36 to the transient monitor.

Planned:

1) GSS and Westinghouse will evaluate the failure mode of the phase shifter circuits.

   NOTE: If the failure mode can be determined, there will be an addendum to this report within 30 days of receipt of the Westinghouse evaluation.

2) GSS will review the need for filtered cooling to the Excitation Switchgear and submit a Station Problem Report if necessary.

3) Performance and Design Engineering will review the setpoint range of the Steam Generator PORVs and make changes as necessary.

4) Instrumentation and Electrical will evaluate compensation voltage adjustment to the Nuclear Instrumentation Intermediate Range channels and the time period after the Reactor Trip or Shutdown when this adjustment can be made.

5) Instrumentation and Electrical will monitor and adjust as necessary the compensating voltage to the Nuclear Instrumentation Intermediate Range channels immediately after the next Reactor Trip or Shutdown.

SAFETY ANALYSIS:

The Reactor Trip was caused by a Turbine Trip above 48% Reactor power. The Turbine tripped on a loss of excitation to the field of the Generator. This Reactor Trip initiating transient is bounded by the "Loss of External Load" and the "Turbine Trip" events of the McGuire Final Safety Analysis Report Accident Analysis, Chapter 15.

Auxiliary Feedwater system motor driven pumps were started automatically approximately 30 seconds after the trip to provide feedwater to the Steam Generators to maintain a heat sink. Minimum level reached was approximately 27% in Steam Generator C. Main Feedwater isolation occurred approximately 30 seconds after the Reactor Trip. All primary system and secondary system parameters necessary to assure a safe shutdown were at or approaching no-load conditions 30 minutes after the trip. Steam Generator PORVs opened to help relieve the pressure transient and the Steam Generator Code Safety Valves [EIIS:RV] were not challenged. NC system PORVs or Code Safety valves were not challenged.

This Turbine Trip/Reactor Trip presented no hazard to the integrity of the NC or Main Steam systems. There were no radiological consequences as a result of this event.

There were no personnel injuries, personnel overexposures, or releases of radioactive material as a result of this event.

This event is considered to be of no significance with respect to the health and safety of the public.

SUPPLEMENTAL INFORMATION:

The following discussion describes the results of the Westinghouse inspection of the malfunction in the Generator Excitation Switchgear Silicon Controlled Rectifier firing circuit.

Introduction

Originally, this event was assigned a Cause of Other because the transient/trip was caused by a malfunction in the Excitation Switchgear Silicon Controlled Rectifier (SCR) firing circuit. The exact cause of the malfunction in the firing circuit could not be determined during the original investigation. However, it was determined when the firing circuit components underwent testing at the Westinghouse testing facility in Asheville, North Carolina, that the failure was caused by a loose solder connection on pin 8 of the phase shifter card Therefore, this event is reassigned a Cause of Manufacturing Deficiency because of this apparent manufacturing defect. This event is also assigned a Contributory Cause of Design Deficiency because the heat, dust, and vibration present at the Excitation Switchgear cabinet exacerbated the original defect.

Results of Phase Shifter Inspection

On March 4, 1988, Westinghouse and GSS personnel began to test the defective firing circuit that caused the Unit 1 Reactor Trip on January 7, 1988. The firing circuit was connected to a 420 Hz, 125 volt power supply and an oscilloscope to monitor the firing circuit output. The firing circuit was heated to approximately 120 degrees F by use of small space heaters and a fan to simulate operating conditions. After several hours of operation and testing by switching phase shifter modules pulling and reinserting pulse cards, and finally heating each pulse card individually, no failures were detected. While attempting to heat each circuit card individually, Westinghouse personnel applied a small amount of pressure to the top of the phase shifter card and the firing circuit pulse shifted to maximum output. After jumpering across pin 8 of the phase shifter card edge connector, Westinghouse personnel caused the firing circuit pulse to return to normal. After a thorough visual inspection, a loose solder connection was found at pin

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8 on the phase shifter card edge connector. The solder connection was repaired, and no further failures could be detected.

GSS personnel believe the loose solder connection was attributable to poor manufacturing by Westinghouse. The problem did not occur immediately when this firing circuit was put in service at the end of the Unit 1 refueling outage in November 1987 because the heat, dust, and vibration in the Excitation Switchgear cabinet caused the poor solder connection to degrade to the point of failure after approximately 6 weeks in operation. The heat and vibration cause premature degradation of components in the Excitation Switchgear cabinet and can cause failure of components that are defective but work properly on a test bench. The dust impedes heat transfer and increases the effects of excessive heat. Actions will be taken to correct the heat and dust problem; however, vibration will still be present due to the excessive costs involved in correcting this condition.

Corrective Actions

Subsequent: The firing circuit was tested and repaired by Westinghouse and GSS personnel and returned to McGuire.

Planned: The Generator Excitation Switchgear cabinets for both Unit 1 and Unit 2 will be enclosed and supplied with filtered and cooled air.

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

HAL B. TUCKFR
VICE PRESIDENT
NUCLEAR PRODUCTION

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July 25, 1988

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

Subject: McGuire Nuclear Station, Unit 1
Docket No. 50-3'9
Licensee Event Report 369/88-01-01

Gentlemen:

Pursuant to 10CFR 50.73 Sections (a)(1) and (d), attached is revised Licensee Event Report 369/88-01 concerning a reactor trip that occurred on January 7, 1988. This revised report is being submitted to describe the results of a Westinghouse inspection of the malfunction in the Generator Excitation Switchgear Silicon Controlled Rectifier Firing circuit, and in accordance with 10CFR 50.73(a)(2)(iv). 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

SEL/109/sbn

Attachment

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