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SUBJECT: LER 94-002-00:on 940406,main feedwater pump 2B tripped on low oil pressure due to equipment failure.Caused by defective procedure.Main feedwater pump preventive maint procedure revised & subj pump repaired.W/940504 ltr.

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May 4, 1994

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

Subject: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287
LER 270/94-02

Gentlemen:

Pursuant to 10 CFR 50.73 Sections (a)(1) and (d), attached is Licensee Event Report (LER) 270/94-02, concerning a reactor trip on loss of both main feedwater pumps.

This report is being submitted in accordance with 10 CFR 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,

J. W. Hampton
Vice President

/ftr

Attachment

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IE22
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NRC FORM 366 (5-92) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104
EXPIRES 5/31/95

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), 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.

LICENSEE EVENT REPORT (LER)

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

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Oconee Nuclear Station, Unit 2	05000 270	1 OF 8

TITLE (4) Reactor Trip On Loss of Both Main Feedwater Pumps Due to Equipment Failure

EVENT DATE (5)			LER NUMBER (6)			REPORT NUMBER (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
04	06	94	94	-- 02 --	00	05	04	94		05000
									FACILITY NAME	DOCKET NUMBER
										05000

OPERATING MODE (9)	N
POWER LEVEL (10)	54

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (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
20.405(a)(1)(iii)		50.73(a)(2)(i)		50.73(a)(2)(viii)(A)	(Specify in Abstract below and in Text, NRC Form 366A)
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 (Include Area Code)
L. V. Wilkie, Safety Review Manager	(803) 885-3518

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
F	SJ	P	G080	Yes					

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 April 6, 1994, Unit 2 was operating at 100 % Full Power (FP) when the 2B Main Feedwater Pump (MFDWP) tripped on low oil pressure at 1047 hours. The Integrated Control System (ICS) automatically ran back reactor power to approximately 54 % FP as designed. Automatic control of the 2A MFDWP was erratic, resulting in feedwater oscillations. As operators were taking ICS stations to manual to control the feedwater swings, the 2A MFDWP tripped on high discharge pressure. This resulted in an Anticipatory Reactor Trip at 1108 hours, due to the loss of both MFDWPs. The response of operators and automatic systems brought the unit to stable hot shutdown conditions. An investigation into the cause of the 2A and 2B MFDWP trips revealed a set screw on the 2A MFDWP's Motor Gear Unit was loose and the Main Shaft Oil Pump gears on 2B MFDWP had failed. The root cause was Equipment Failure with a contributing cause of Defective Procedure (technical deficiency). Corrective actions included revising the MFDWP's preventive maintenance procedure, replacing the set screw, and the repair of 2B MFDWP.

BACKGROUND

The Integrated Control System (ICS) [EIIS:JA] provides fully automatic control of reactor power, steam generation rate, and generated load by processing selected signals of measured plant parameters.

The Reactor Protective System (RPS)[EIIS:JC] monitors parameters related to the safe operation of the plant and protects against fuel clad damage and the Reactor Coolant System against damage caused by high system pressure. There are four RPS channels, with two out-of-four logic to produce a reactor trip signal. The generated trip signal will open all Control Rod Drive breakers. Two anticipatory trip signals will actuate the RPS. One of the reactor trip signals is the Main Turbine Trip Anticipatory Trip and another is both Main Feedwater (FDW) Pumps Trip Anticipatory Trip. Each of these will produce an RPS signal to trip the reactor if proper conditions exist.

The Main FDW system takes suction from the Condensate [EIIS:SD] system, further preheats the feedwater in the feedwater heaters and delivers FDW to the Steam Generators (SG) with two steam driven FDW pumps. ICS controls the amount of flow by throttling two sets of control valves, one set for each SG, and controlling FDW pump speed to ensure pump discharge pressure is sufficient to force water into the SGs.

Main Feedwater Pump Turbine speed is controlled by the Motor Speed Changer (MSC) and the Motor Gear Unit (MGU), which are located in the front standard of the pump. The MSC has full range control, but is normally used to control the speed from zero to approximately 2800 rpm. The MGU is used to control the speed from approximately 2800 rpm to the speed required for plant conditions utilizing ICS.

The Emergency Feedwater System (EFDW) [EIIS:BA] is designed to start automatically upon the loss of FDW. Both Motor Driven Emergency Feedwater pumps and the Turbine Driven Emergency Feedwater pump will automatically start on a loss of both FDW pumps. SG levels will be controlled automatically by the EFDW Control Valves. All EFDW automatic initiation logic and control features are independent of the ICS.

EVENT DESCRIPTION

On April 6, 1994, at 0601 hours, the 2A Motor Driven Emergency Feedwater Pump (MDEFDWP) was removed from service to perform a minor modification.

At 1047:13 hours, with Unit 2 operating at 100 % Full Power (FP), 2B Main Feedwater Pump (MFDWP) tripped due to low oil pressure. This resulted in a Integrated Control System (ICS) runback of reactor power to approximately 54 % FP. Automatic control of the 2A MFDWP was erratic, resulting in feedwater oscillations.

In an attempt to control the feedwater oscillations, operators placed the ICS Feedwater Master and Steam Generator/Reactor Master in manual at approximately 1103 hours. However, the feedwater oscillations continued and the remaining 2A MFDWP tripped at 1108:17 hours on high discharge pressure. This resulted in both Feedwater Pump trip Anticipatory trip, Reactor Protective System Channels A, B ,C, and D tripped, which initiated a Reactor trip.

All full length control rods [EIIS:ROD] fully inserted into the core and the reactor was shutdown.

At 1108:17 hours, the 2B MDEFDWP auto started and the Turbine Driven Emergency Feedwater Pump (TDEFDWP) auto started at 1108:32 hours. The 2A MDEFDWP had been taken out of service for a modification. The modification involved replacing a cable for a pressure switch which affected the automatic start and did not affect the mechanical aspects of the pump.

Operators took manual actions per the Emergency Operating Procedure (EP/2/A/1800/001). As normally required after a reactor trip, the operators started a second High Pressure Injection (HPI) [EIIS:CB] pump at approximately 1109 hours and opened 2HP-26, HPI Emergency Make-up Valve, to maintain Pressurizer level. At approximately 1115 hours, the operators closed 2HP-26 and stopped the second HPI pump.

Post trip parameters remained within acceptable limits. Reactor Coolant System (RCS) [EIIS:AB] pressure decreased to a minimum of 1841 psig and then increased to a maximum of 2203 psig before controlling at 2155 psig. Pressurizer inventory varied from a high of 185 inches to a low of 86 inches before controlling at approximately 162 inches. RCS temperature converged to approximately 552 F, following the trip. Steam Generator (SG) A pressure immediately increased to 1074 psig following the trip and decreased to 938 psig before controlling at 1000 psig. SG B pressure immediately increased to 1051 psig following the trip before decreasing and

controlling at 1000 psig. Both SG levels decreased to minimum of 27 inches before stabilizing at 30 inches.

At 1132 hours, the 2B MDEFDWP was stopped and placed in auto.

Following the trip it was discovered that the event recorder indicated that the "E" breakers had two rapid transfers. This was evaluated and it was determined that the "E" breakers would close and supply power to the unit. Therefore, this will not prevent the operation of safety related equipment if called upon during a unit trip. This was entered into the Problem Investigation Process for further investigation to determine proper corrective action.

An investigation began into the cause of the 2A and 2B MFWDP trips. After several hours of troubleshooting and inspection, Instrument and Electrical technicians and Engineering personnel identified the cause of 2A MFDWP's inability to control feedwater. A set screw which fastens a gear to a rotating shaft on the Motor Gear Unit (MGU) was discovered to have been loose. This allowed the gear to slide on the rotating shaft, thus making auto and manual control erratic.

It was also discovered that the 2B MFDWP's Main Shaft Oil Pump (MSOP) had failed. The MSOP driver and driven gear teeth had been stripped. Engineering determined that the MSOP driver gear's locknut had not been torqued properly. Also the key which holds the gear in place was a stock key and was slightly smaller than the keyway, therefore allowing some movement of the gear on the shaft.

Prior to 1991, maintenance on the MFDWPs was performed without the use of a procedure. In 1991, Maintenance Procedure MP/0/B/1320/13 (Pump-Feedwater-Turbine-Front Standard-Preventive Maintenance of Hydraulic Control Oil System) was issued to provide guidelines for preventive maintenance inspections on components located in the front standard. The procedure was compared to the manufacturer's instructions. Technical Information Letters (TIL) 74-2 and 76-2 were discovered from General Electric, TIL 74-2 issued on May 24, 1974 and supplemented by TIL 76-2 on March 24, 1976. TIL 74-2 was issued due to reports of loose gears on feed pumps with shaft oil pumps and recommended that locknuts be torqued to 197 foot pounds. TIL 76-2 was issued to inform customers of areas which should have special attention and recommended that proper fit of the key in both the shaft and gear is essential. No documentation was found which required the set screw on the MGU to be staked. MP/0/B/1320/013 (Revision 0) was last performed on June 11 and June 8, 1993 on 2A and 2B MFDWPs, respectively. The Maintenance Procedure did not include the TIL recommendations.

An interview with the responsible Component Engineer (CE) revealed that the method used for tightening locknuts prior to this event was a hammer and drift pin. This method did not ensure that a consistent torque was being applied to the locknuts.

On April 6, 1994, at 1328 hours the 2A MDEFDWP was returned to service and both the 2A and 2B MDEFDWPs were manually started. At 1329 hours, the TDEFDWP was stopped and placed in auto. This was performed per the Abnormal Procedure (Loss Of Main Feedwater).

At approximately 2010 hours, a new set screw which fastened a gear to the rotating shaft on the MGU was installed with an adhesive. The MGU was functionally tested and found to be operating as required. The 2A FDWPT was placed in service to feed the SGs. At this time the 2A and 2B MDEFDWPs were stopped and placed in auto.

On April 9, 1994, at 1700 hours, repairs and testing were completed on the 2B MFDWP. The MSOP driver and driven gears were replaced along with the pump shaft and jackshaft. The MSOP driver gear was torqued and fitted keys were installed. The 2B MFDWP was placed in service and the 2A MFDWP was taken out of service to inspect it's MSOP and repair if necessary.

At 1806 hours, Unit 2 was returned to criticality.

The inspection of the 2A MFDWP revealed that the driver gear and driven gears were in good condition; however, the gears did have some indications of slight wear. In addition, it was discovered that the driver gear locknut and the locking tab were loose. A decision was made to replace both shafts, gears, and torque locknuts. The repairs were performed, the 2A MFDWP was tested and returned to service on April 11, 1994.

CONCLUSIONS

The root cause of this event is determined to be equipment failure. A set screw which fastens a gear to a rotating shaft on the Motor Gear Unit (MGU) was discovered to have been loose. The loose set screw allowed the gear to turn on the shaft, causing control instability of the 2A Main Feedwater Pump (MFDWP), resulting in a MFDWP trip on high discharge pressure. The screw apparently worked loose due to normal vibrations.

A contributing cause of this event is Deficient Procedure, technical deficiency. MP/0/B/1320/013 did not specify a torque value for the locknuts and did not require the key to be machine fitted into the keyway. If this procedure had specified these requirements, the failure of the gears within the 2B MFDWP may have been prevented. Due to the time elapsed

since the Technical Information Letters (TIL) were received at Oconee and lack of documentation, it could not be determined what considerations were given to the TILs at the time of receipt.

An incident with a similar problem to the MSOP problem occurred on November 8, 1993 on Unit 1's 1B MFDWP. As a result of abnormal noises and vibrations on the MFDWP, unit load was reduced to 65% FP to investigate. It was discovered that the Main Shaft Oil Pump's driver gear had five broken teeth and the drive gear on the jackshaft had one broken tooth. The gears were sent to the Applied Science Center for metallurgical examination to determine the root cause of failure. The examination concluded that there was some misalignment in conjunction with metal fatigue. The gears were replaced and changes were made to MP/0/B/1320/013 to require a Non Destructive Examination of the gears during each front standard teardown. During Unit 3's subsequent refueling outage the locknuts were torqued to the specified value and the key was machine fitted. However, the procedure was not changed to incorporate these requirements. This indicates that the problem associated with the MSOP is recurring.

Over the last two years there have been six reactor trips at Oconee Nuclear Station with root or contributing causes of equipment failure. These were reported as LERs 269/92-03, 270/92-04, 270/93-01, 269/93-10, 269/94-02, and 287/94-01. In each of these cases, the systems, components, and mode of failure have been different. Therefore, this event is not recurring.

The failure of the MFDWP is NPRDS reportable. The MFDWP and turbine was supplied as an assembly by General Electric but does not have an assigned model number. The failed components are part of the turbine which is a Type DRV631, six stage, dual inlet turbine.

There were no personnel injuries, radiation overexposures, or releases of radioactive materials associated with this event.

CORRECTIVE ACTIONS

Immediate

1. Operators took actions per procedure to bring the unit to stable hot shutdown.

Subsequent

1. A new set screw was installed with an adhesive on the 2A Main Feedwater Pump's (MFDWP) Motor Gear Unit.

2. The 2B MFDWP Main Shaft Oil Pump's (MSOP) gears, pump shaft, and jackshaft were replaced. The locknuts were torqued to the specified value and the keys were machine fitted.

3. The 2A MFDWP's MSOP's gear was inspected and did have indications of slight wear. The gears, pump shaft, and jackshaft were replaced. The locknuts were torqued.

4. 2B MFDWP's MGU set screw was inspected and found to be staked.

Planned

1. MP/0/B/1320/013 will be revised to include a torque value for locknuts, machine fit keys, and stake the set screw on the motor gear unit.

2. 1A and 1B MFDWP Turbine's Motor Gear Unit set screw will be staked and adhesive applied during the next Unit 1 outage of sufficient duration to perform this task.

3. 2A and 2B MFDWP Turbine's Motor Gear Unit set screw will be staked and adhesive applied during the next Unit 2 outage of sufficient duration to perform this task.

4. 3A and 3B MFDWP Turbine's Motor Gear Unit set screw will be staked and adhesive applied during the next Unit 3 outage of sufficient duration to perform this task.

5. Maintenance on Unit 1's MFDWP Turbines will be performed in accordance with the latest revised MP/0/A/1320/013, which includes a requirement for machine fitted keys and torque value for locknuts.

SAFETY ANALYSIS

Loss of Main Feedwater (MFDW) is an anticipated transient and is described in Section 10.4 of the Final Safety Analysis Report. Loss of MFDW initiates a reactor trip and starts the Emergency Feedwater (EFDW) System to provide decay heat removal. In this event, all the systems and equipment operated as designed to mitigate the consequences of the loss of MFDW. Instrumentation detected the loss of MFDW and the Main Turbine and initiated the Reactor trip and provided the start signal to the EFDW system. The Turbine Driven Emergency Feedwater Pump Turbine and one Motor Driven Emergency Feedwater Pump (MDEFDWP) started. The unit was stabilized at hot shutdown. The other MDEFDWP had been removed from service due to a modification, but was restored to service approximately two and one half hours into the event.

If the affected unit's EFDW pumps had not started, the Emergency Operating Procedures (EOP) and Abnormal Procedures (AP) direct operators to align EFDW from one of the other two Oconee units. The EOP and AP also includes the use of High Pressure Injection forced cooling and/or use of the Standby Shutdown Facility Auxiliary Service Water pump. Analyses have been performed to verify that sufficient time is available for an operator to line up these systems before any core damage would occur.

There were no releases of radioactive materials, radiation over-exposures, or personnel injuries associated with this event. The health and safety of the public was not affected by this event.