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December 1, 1989
LIC-89-1036

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station P1-137
Washington, DC 20555

Reference: (1) Docket No. 50-285
(2) Licensee Event Report 89-016, July 17, 1989
(3) Licensee Event Report 89-016, Rev. 1, September 1, 1989

Gentlemen:

Subject: Licensee Event Report 89-016, Rev. 2 for the Fort Calhoun Station

Please find attached Licensee Event Report 89-016, Revision 2 dated December 1, 1989. Revised or supplemental information is noted by vertical bars in the margins. This report is being submitted per requirements of 10 CFR 50.73(a)(2)(i)(B) and 50.73(a)(2)(ii)(B).

If you should have any questions, please contact me.

Sincerely,

K. J. Morris
Division Manager
Nuclear Operations

KJM/tcm

Attachment

c: R. D. Martin, NRC Regional Administrator
A. Bournia, NRC Project Manager
P. H. Harrell, NRC Senior Resident Inspector
INPO Records Center
American Nuclear Insurers

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NRC FORM 366 (6-89)

U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1): Fort Calhoun Station Unit No. 1

DOCKET NUMBER (2): 0 5 0 0 0 2 8 5

TITLE (4): Auxiliary Feedwater Pump FW-10 Outside Design Basis

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 6	1 6	8 9	8 9	— 0 1 6 —	0 2	1 2	0 1	8 9	N	0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9): 1

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)	[ ] 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)	[X] 50.73(a)(2)(i)	[ ] 50.73(a)(2)(viii)(A)	
[ ] 20.405(a)(1)(iv)	[X] 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	
W. E. Stecker, System Engineer	4 0 2	5 3 3 - 6 8 9 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
E	B A	P D T	X 9 9 9	Y		E	B A	P C O	X 9 9 9	Y
E	B A	P C O	X 9 9 9							

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 June 16, 1989, Engineering evaluation of test results revealed that, for an unknown period prior to June 14, 1989, Auxiliary Feedwater Pump FW-10 operability was outside the design basis for certain accident conditions due to inoperability of the pump pneumatic speed control loop. Problems with the control loop had been found on June 13, 1989 after FW-10 was taken out of service for special testing. These problems would have limited pump speed and discharge pressure below that needed to inject water into the steam generators under some accident conditions. Because the control loop could not be repaired and tested expeditiously, the air supply to the control loop was valved out on June 14, 1989. This allowed pump speed and discharge pressure to be controlled by the mechanical speed limiter on the main governor as designed to meet accident mitigation criteria. The pump was determined to be operable and returned to service. An investigation was initiated to determine the duration and cause of the control loop inoperability. The NRC Regional Office was briefed on June 13, 1989 and, following the determination of reportability, the NRC Operations Center was notified on June 16, 1989 at 1646 hours, pursuant to 10 CFR 50.72(b)(1)(ii). Fort Calhoun Station Unit No. 1 was at approximately 100% power at the time of determination. Inoperability of the control loop was due to inadequate preventative maintenance, surveillance testing, and configuration control. A comprehensive action plan has been implemented and corrective actions have been initiated.

Auxiliary Feedwater Pump FW-10 is one of two redundant auxiliary feedwater pumps at Fort Calhoun Station Unit No. 1. FW-10 is a steam turbine driven pump designed to be independent of AC power requirements, while redundant pump FW-6 is an AC motor driven pump. Each pump is designed to deliver a minimum flow of 260 gallons per minute (gpm) to the steam generators against a steam generator pressure of 1000 psia. During normal startup and shutdown operations, pump FW-6 is routinely used to supply feedwater. Pump FW-10 is not normally used for plant operations and is usually only run during testing. Both auxiliary feedwater pumps are designed to automatically start on low steam generator level. If a loss of all station AC power also occurs, FW-10 is the primary source of feedwater. However, motor-driven pump FW-6 can be powered from an emergency diesel generator after normal AC power supply is lost.

The speed (and resultant discharge pressure) of FW-10 is designed to be governed by a pneumatic-hydraulic speed control loop which maintains the feed pump discharge pressure at a fixed differential greater than the steam generator pressure. A Moore differential pressure transmitter (PT-1039) senses the differential pressure between the pump discharge and the steam generator and sends a signal to a pneumatic controller. The Nullmatic Two-Mode Model 55M controller (PC-1039) feeds an air signal through a Nullmatic Model 59 derivative controller unit which dampens the signal to reduce pump speed oscillation. This should permit smooth response to a pump speed needed to provide discharge pressure above steam generator pressure. The differential pressure setpoint is adjustable in the field, and would normally be set so that the pump discharge pressure is at least 40 psi above the steam generator pressure at rated flow. The pump control system is supplied from the Instrument Air System. The control system is also designed to allow maximum speed of the pump upon total loss of Instrument Air. In this condition, pump speed is limited by the setting of the mechanical speed limiter on the main governor. As originally installed, the speed control loop did not provide for manual control of pump speed.

At 1300 hours on June 13, 1989, with the station operating at 100% power, pump FW-10 was taken out of service in preparation for testing following redundant component testing of pump FW-6. Technical Specification 2.5 allows one auxiliary feedwater pump to be inoperable for up to 24 hours. The testing (controlled by procedure SP-FW-12) was intended to provide baseline data on pump performance by developing a method for manual control of pump speed, in order to establish a reference speed for future testing and verify the governor-limited maximum speed. Temporary modification 89-M-031 was implemented, which installed a variable air supply test-tee inlet to the control loop in order to simulate signals from the differential pressure sensor and provide manual pump speed control to the test personnel. At 1645 hours, FW-10 was started and warmed up for the test. At 1727 hours the test air supply was valved in and initial readings were taken. Between the hours of 1750 and 1835 the test air pressure signal was varied numerous times with no change in pump speed observed. At 1835 hours the pump was stopped and the control system was returned to normal configuration. The Shift Supervisor, Duty Supervisor, System Engineering Supervisor, and Plant Manager were informed of the situation.

At 2000 hours on June 13 an emergency maintenance order was initiated to investigate and make minor repairs to the pneumatic controller and derivative unit. This activity included cleaning of restriction orifices and checking adjustments of the controller as described in the vendor manual. The pneumatic derivative unit was found to be leaking air and to have erratic response. No other repairs or adjustments were possible at the time. With the control components in this condition, pump FW-10 maximum speed was found to be 6980 rpm with a resultant discharge pressure of 996 psig, a value below the minimum pressure required for operability during a Design Basis Accident.

Test procedure SP-FW-12 was revised to allow determination of the mechanical limiter setpoint on the main governor for FW-10 by injecting the test signal downstream of the derivative unit. The test revealed on June 14 at 1005 hours that, upon loss of instrument air supply, pump speed would increase to 7725 rpm with a discharge pressure of 1210 psig. In this mode the pump was considered operable, since the speed and discharge pressure were well above the design basis minimum values, yet pump speed was within the maximum allowable. It was determined that failure analysis and repairs of the pneumatic controller components could not be accomplished within the remaining degraded mode period allowed by the Technical Specifications, so the instrument air supply to the control system for FW-10 was valved out. The pump was restarted to verify that it would perform its intended safety function in this configuration; it was subsequently declared operable and returned to service at 1130 hours on June 14 with the instrument air supply valve tagged closed.

It could not be immediately determined what caused the malfunction of the controller system or when the system became inoperable. An evaluation including review of previous test data was initiated in order to determine reportability. Because of the significance of the event, the situation was explained to the NRC Region IV office by plant management on June 14. The engineering evaluation concluded on June 16, 1989 that FW-10 controller loop performance was degraded for at least several years prior to discovery; the plant thus operated outside the design basis of the auxiliary feedwater system for an indeterminate period. This was reported to the NRC Operations Center on June 16, 1989 at 1646 hours pursuant to 10 CFR 50.72(b)(1)(ii). As an additional consequence, the Limiting Condition for Operation (LCO) of Technical Specification 2.5 was violated for an indeterminate period.

This event is safety significant to the degree that, under certain conditions, Auxiliary Feedwater Pump FW-10 would not have been capable of performing its function. These conditions would be the coincident (1) loss of main feedwater, (2) unavailability of motor-driven Auxiliary Feedwater Pump FW-6, (3) steam generator pressure over approximately 1000 psia, and (4) availability of Instrument Air supply to FW-10. The pneumatic controller problems limited FW-10 discharge pressure to approximately 996 psig. Further analysis of the safety consequences of this event was performed, with results noted in Action Item (8) of this report.

An action plan was formulated to address cause, consequences, and corrective actions for this event, and to resolve concerns and questions from NRC Region IV inspectors. The action plan items and results are:

(1) Determine the direct cause of the derivative controller failure in the FW-10 speed control loop.

A Special Procedure SP-FW-13 was performed to control the trouble-shooting and repair of the speed control loop on FW-10. The pneumatic controller vendor participated in the effort. The failure of the derivative unit was caused by excessive clearances which developed between close tolerance parts within the unit during its installed life. These increased clearances between the diaphragms and nozzles caused erratic operation and eventual complete failure of the unit. The body bolts which hold the stacked body parts together were found to be loose. Similar problems of increased clearances and loose body bolts were found with the two-mode controller upstream of the derivative unit. In addition, the zero setpoint adjustment screw on the two-mode controller was found turned to the extreme clockwise position further prohibiting the normal functioning of the unit. When and why this adjustment was made could not be determined.

Both of the units were removed to the shop and disassembled for inspection. No evidence of moisture or foreign material intrusion was found. The diaphragms were found to be slightly stiff or embrittled but not cracked or flaking off. The looseness of the body bolts was attributed to the permanent deformation of the edges of the diaphragms due to aging and compression. New controllers have been calibrated and installed in the loop on FW-10.

During the trouble-shooting process the differential pressure transmitter was also found to have failed. The bellows leaked internally resulting in failure to respond to differential pressures applied at the inputs. A replacement transmitter has been ordered. For this reason, the speed control loop of FW-10 remains out of service with its air supply valve tagged shut. Disassembly and inspection of the transmitter to determine its failure mechanism will be conducted after replacement parts are received.

The Moore Products field representative has recommended that the body bolts on the Moore controllers be torqued to 55 inch-pounds and checked periodically. This information has been transmitted to the Project 1991 preventive maintenance (PM) program upgrade group for evaluation and inclusion in the appropriate PM procedures. As noted above, the FW-10 controller loop remains out of service due to the failed bellows in the differential pressure transmitter. The replacement of this transmitter is expected to occur by January 31, 1990, subject to receipt of ordered parts. Appropriate calibration and PM procedures will be in place prior to returning the control loop to service.

(2) Determine the root cause of the failure of FW-10 to respond to manually injected air signals during the conduct of SP-FW-12.

A root cause investigation was conducted by members of the Nuclear Safety Review Group. The root cause was determined to be failure to include the speed control loop for FW-10 in the preventative maintenance/calibration program at initial plant startup. Subsequent investigation by the Nuclear Safety Review Group determined the following contributing factors: the control loop components were never classified as CQE, and an inadequate surveillance test did not verify the proper operation of the speed control loop.

(3) Review and evaluate available information to ascertain, if possible, when failure/misadjustments of the speed control components occurred.

Immediately following the discovery of the failure of FW-10 to respond to pneumatic test control signals, a review of past surveillance test data (ST-FW-1) was initiated. Several different test result parameter combinations were graphed to find a trend or pattern that would indicate when the failure might have occurred. A graph depicting the trends of turbine steam inlet pressure, and the pressure differential between the pump discharge and steam inlet was constructed.

The data indicate that, since July, 1985, the differential pressure between pump discharge and steam inlet pressures varied inversely with the steam inlet pressure changes. If the pump speed control loop had been operating properly, this differential pressure trend would be a relatively straight line. The inverse relationship was caused by the pump operating at a constant speed, and therefore constant discharge pressure, due to the control loop being unresponsive. That is, no matter what the air input signal from PT-1039, the turbine throttle linkage positioner output air signal remained at approximately 12 psig output, causing the pump to operate at a relatively constant speed. This speed was not sufficient for developing the head required for the pump to fulfill its safety related function during a DBA. Therefore, it is concluded that since July 1985, the pump speed control loop was inoperable causing FW-10 itself to also be inoperable.

Prior to July 1985, the test data points for the pump discharge pressure /steam inlet pressure differential were widely variable, indicating that the control loop was not properly functioning. However, the pump did operate at sufficient speeds to develop the discharge pressure necessary for injection of water into the steam generators under DBA conditions. Therefore, although the controller may not have been fully operable prior to July 1985, it did not restrict the speed of the pump enough to cause FW-10 to be inoperable.

(4) Review previous testing of FW-10 to determine if the failure of the speed control loop should have been evident from the data available. Evaluate the effectiveness of the existing surveillance tests on FW-10 used to demonstrate operability.

A review of previous testing of FW-10 per ST-FW-1 was performed by OPPD Special Services Engineering to determine if the failure of the speed control loop should have been evident from the data available. As evidenced by the resolution of Action Item #3, the surveillance test did contain sufficient information to determine that a problem existed with the speed control loop. However, the pattern that indicated a failure was discovered only after much manipulation of the available data. In addition, until 1988, there was no AFW system expert (system engineer) with the detailed knowledge of the operation of FW-10 which is necessary to properly review the surveillance test for deficient trends or patterns such as this. These facts, coupled with the fact that the failure occurred prior to the implementation of a formal surveillance trending program, make it highly improbable that the failure of the speed control loop would have been recognized by the test reviewers.

A review of ST-FW-1 was also performed by Special Services to evaluate the test's effectiveness in demonstrating the operability of FW-10. This evaluation revealed the following deficiencies:

A) Turbine steam bowl pressures were not recorded or trended. The pump vendor has stated that trending of this parameter is one of the best indicators of pump and/or turbine performance degradation. This parameter is now incorporated into ST-FW-1.

B) Prior to April, 1989, ST-FW-1 did not provide for a means of directly measuring pump suction pressure, which is used to determine pump developed head. Suction pressure was calculated from a static elevation head measurement at the emergency feedwater storage tank. This methodology has been changed by directly reading suction pressure from a test gauge installed at the pump's suction flow element. This results in a much more accurate indication of pump developed head and provides assurance that no operability concerns exist with the pump's suction supply.

C) ST-FW-1 did not require a variation from the steady state speed obtained when the pump was started and run in the recirculation flow configuration. If ST-FW-1 would have required such a speed variation to be performed, the inoperability of the speed control loop would have been evident at the time an individual test was performed.

D) The surveillance program did not require that the full flow capability of the AFW pumps be measured periodically. In fact, the full flow capabilities of FW-6 and FW-10 were never adequately determined until April 1989. Both INPO and the NRC have stated that periodic full flow testing is desirable for determining pump operability. The installation of modification MR-FC-88-017 will provide a full flow test line for FW-6 and FW-10. The installation and testing activities for this modification are scheduled for completion by July 30, 1990, contingent on equipment delivery. A periodic full flow test procedure will be developed and performed for both FW-6 and FW-10 within two months following the modification installation and testing completion date. Special full flow testing of FW-6 and FW-10 will be conducted immediately before and after the 1990 Refueling Outage, respectively.

Considering the above deficiencies, the surveillance test ST-FW-1 was not adequate in demonstrating the operability of FW-10 prior to April, 1989.

(5) Investigate why the speed control loop components have had no equipment identification numbers, calibration procedures, or periodic maintenance. Evaluate whether speed control loop components are correctly classified with respect to EEQ, safety class, and procurement class (CQE, etc.).

Investigation revealed that two speed control loop components did have assigned equipment numbers: The Differential Pressure Transmitter is PT-1039, and the Two-Mode Nullmatic Controller is PC-1039. The Derivative Nullmatic Unit and the Fisher Positioner and Linkage Actuator were not uniquely identified.

Several factors appear to have contributed to the fact that these instruments were not included in the preventative maintenance/calibration programs during and after initial plant startup: the instruments were supplied skid mounted with FW-10; the instruments were never identified as CQE (or safety related); the instruments were not identified on the startup instrument punch lists; and the instruments were always considered to be part of the Main Steam system (steam supply to FW-10) instead of the Auxiliary Feedwater system.

An investigation by OPPD Design Engineering was conducted into the proper classification of the components in the speed control loop on FW-10. Their conclusions are summarized below:

A) The speed loop components should be classified as seismic Class 1 and CQE and maintained as such.

B) The speed loop components are not EEQ.

An Engineering Change Notice has been processed to accurately depict the configuration of the control loop in the field. Unique identification numbers have been assigned to the individual loop components which were not previously tagged. The CQE list, the CHAMPS data base, and the AFW design basis document have been updated.

(6) Evaluate the design basis of and the need for the differential pressure controller on FW-10. The results of this evaluation are summarized below.

The FW-10 speed control loop is designed to limit pump discharge pressure to a setpoint sufficiently above steam generator pressure to permit injection at the required flow rate under various operational and design basis event conditions. The primary advantage of the existing speed control loop design is that it allows the pump to run at optimum speeds, sufficient to meet system head requirements while minimizing pump and valve wear. This efficiency feature is particularly advantageous for injection into a steam generator with decaying pressure conditions (i.e., long term heat removal). The disadvantage of this control configuration is the increased complexity over the alternative considered.

The best alternative to the current design was determined to be a constant pressure control scheme, which would control pump speed to maintain a constant discharge pressure output regardless of system total head requirements. The controller setpoint would have to be high enough to ensure system operation at worst case design basis event conditions. The disadvantage of this approach is the resultant high differential pressures across the downstream throttle valves under normal operating conditions, causing higher wear rates for the pump and the throttle valves. The primary advantage of this design is its simplicity.

It was concluded that the present variable speed control design is most appropriate for this application. Repairs to restore the FW-10 speed control loop to operability are expected to be complete by January 31, 1990, subject to receipt of ordered parts.

(7) Evaluate a loss of instrument air event to determine, if possible, the length of time between the loss of air and the instrument air pressure dropping low enough to cause FW-10 to operate on the speed limiter. Include an evaluation of the impact of this time delay on events involving a demand for FW-10. The results of this evaluation are summarized below.

In its present configuration with the instrument air supply valve shut, FW-10 is considered operable; the evaluation for this action item covered the period prior to June, 1989 when the speed control loop was inoperable. A loss of instrument air pressure to below approximately 20 psi, the setpoint of the in-line air regulator, would have initiated an increase in FW-10 speed to the mechanically limited maximum. However, the length of time for air pressure to drop below 20 psi would depend on several variables, including the type of initiating event and the instrument air system usage rate. For events involving no breach of the instrument air system and a loss of offsite power, the rate of instrument air depressurization would likely be low. It is impractical to accurately determine the interval between loss of instrument air and FW-10 reaching maximum speed for all events involving a loss of instrument air. Also, the anticipated operator response to most events would include restarting of an air compressor, using emergency power, long before air pressure degraded to 20 psi. For these reasons, it can be conservatively concluded that FW-10 would have been unable to mitigate certain accident conditions, since credit cannot be taken for immediate and continuing loss of instrument air pressure.

(8) Evaluate the as-found condition of FW-10 for a loss of main feedwater design basis event concurrent with failure or unavailability of FW-6. The results of this evaluation are summarized below.

A review of USAR Chapter 14 indicated that for design basis events demanding auxiliary feedwater flow for mitigation, the most limiting event is the small break LOCA concurrent with a loss of offsite power and single failure or unavailability of FW-6. The loss of offsite power would cause loss of main feedwater and loss of instrument air and thus bounds a loss of main feedwater event.

In this scenario, steam generator pressure is assumed to be 1000 psia. As discussed in Item (7) above, no credit was taken for full operability of FW-10, since it is assumed Operations would power an instrument air compressor from an emergency power bus, limiting FW-10 discharge pressure to the as-found value of approximately 996 psig (1010.7 psia). If piping frictional losses and head differential are taken into account, FW-10 would not have been able to provide auxiliary feedwater to the steam generators. In this situation, procedure EOP-20, RCS and Core Heat Removal Success Path HR-4 directs the operators to initiate once-through-cooling utilizing safety injection pumps, which ensures adequate core cooling until secondary side pressure is sufficiently reduced.