NRC FORM 366 (4-95)

U.S. NUCLEAR REGULATORY COMMISSION

APPROVED OMD NO. 3150-0104
EXPIRES: 04/30/98
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LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Oconee Nuclear Station, Unit One	05000 269	1 OF 9

TITLE (4)
Reactor Building Cooling Units Technically Inoperable Due To 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 NAME	DOCKET NUMBER(S)
									Oconee, Unit Two	05000 270
01	24	97	97	- 02	- 02	09	14	98	Oconee, Unit Three	05000 287

OPERATING MODE (9)	N	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR (Check one or more of the following) (11)			
POWER LEVEL (10)	0	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) (D)	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	
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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)			EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
	YES (If yes, complete EXPECTED SUBMISSION DATE)	X NO				

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

In response to NRC Generic Letter 96-06, Oconee Engineering has been performing conservative analyses to determine if the Low Pressure Service Water (LPSW) System piping which serves the Reactor Building Cooling Units (RBCU) may be susceptible to waterhammer. On 1/24/97, at 1426 hours, the NRC was notified per 10 CFR 50.72 because the analysis determined that, during certain design basis scenarios, waterhammers might occur in piping to the non-safety related auxiliary cooling units (ACUs). This might prevent the safety related RBCUs from performing their intended function. At that time, Units 1 and 2 were at Cold Shutdown and Unit 3 was in a refueling outage. On 2/20/97, revision 0 was submitted as a partial LER because more detailed analyses were still in progress. On 7/31/97, revision 1 was submitted to better describe the potential impact of water hammers in the ACUs. On 8/13/98, after further analysis identified some initial conditions that might result in severe waterhammer and breach LPSW piping serving the RBCUs, the NRC was again notified per 10 CFR 50.72. The root cause is deficient Design Analysis, Unanticipated interaction of systems. Corrective actions included initially isolating and draining the ACU piping, and revising operating procedures as required. This event is considered to be of no significance with respect to the health and safety of the public.

Background

The Low Pressure Service Water (LPSW) System [EIIS:BI] is a raw water support system that takes suction from the Condenser Circulating Water (CCW) [EIIS:BS] Crossover and supplies cooling water to safety and non-safety related loads in the Turbine Building [EIIS:NM], Auxiliary Building [EIIS:NF], and Reactor Building (RB) [EIIS:NH].

Safety Related Cooling Loads include the following:

- Low Pressure Injection (LPI) [EIIS:BP] Coolers
- Reactor Building Cooling [EIIS:BK] Units (RBCUs)
- High Pressure Injection [EIIS:BG] Pump Motor Bearing Coolers
- Motor Driven Emergency Feedwater [EIIS:BA] Pump Motors
- Turbine Driven Emergency Feedwater Pump Bearing Jacket Cooler

The LPI coolers and the RBCUs are supplied by separate LPSW supply lines. The return lines from the LPI coolers and the RBCUs maintain separation to a point beyond a remote-operated isolation valve.

Three (per unit) RBCUs ("A," "B," and "C") are supplied by individual lines from separate LPSW supply headers. Each inlet and discharge line is provided with a motor operated shutoff valve located outside the RB. This allows each RBCU to be isolated individually. During normal operation, the "A" and "C" RBCUs receive throttled flow. Inside the RB the "B" RBCU supply flow is isolated by valve LPSW-566 and diverted through valve LPSW-565 to the four Reactor Building Auxiliary Cooling Units (ACU) to assist normal RB cooling. The ACUs were installed by modification in 1980 to 1982. Flow to the ACUs is automatically isolated (LPSW-565 closes) by an Engineered Safeguards (ES) [EIIS:JE] signal returning full flow to the "B" RBCU (LPSW-566 opens). An ES actuation opens the outlet valves on the three RBCUs to assure emergency flow. During normal operation, the fan motors associated with RBCU "A" and "C" operate in HIGH and the fan motor associated with the "B" RBCU is off. Upon ES actuation, the fan motors associated with the RBCUs operating at high speed (A and C) change to low speed, and the idle unit (B) is energized at low speed.

Description of Event

On September 30, 1996, the NRC issued Generic Letter (GL) 96-06, "Assurance of Equipment Operability and Containment Integrity during Design-Basis Accident Conditions". A portion of this GL identified a concern that cooling water systems serving containment air coolers might potentially experience waterhammer during certain design basis accidents.

Engineering began conservative thermal-hydraulic analyses to determine if any portions of the Low Pressure Service Water (LPSW) System piping which serves the Reactor Building Cooling Units (RBCU) and Reactor Building Auxiliary Cooling Units (ACU) might be susceptible to waterhammer.

On January 24, 1997, Units 1 and 2 were at Cold Shutdown and Unit 3 was in a refueling outage. Engineering determined that a condensation induced waterhammer might occur and possibly cause a pipe break in the LPSW supply to the ACUs. The LPSW flow would be diverted from the RBCUs to the pipe break location and might result in inadequate flow to the RBCUs. In addition, flow from the LPSW piping break would result in boron dilution of the Reactor Building Emergency Sump water. This condition was conservatively reported to the NRC per 10 CFR 50.72, based on the preliminary results from the GL 96-06 review.

As a temporary compensatory action, the ACUs for each Oconee unit were isolated and drained, making the Reactor Building Cooling system operable. The effect of operation without the ACUs was evaluated, prior to restarting each Reactor. Isolation of the ACUs eliminated the potential for condensation induced waterhammer, while further analyses continued. Engineering began more detailed analyses to determine whether the postulated waterhammer might have impacted the integrity of the LPSW piping.

On March 13, 1997, the NRC was notified that engineering analyses were still in progress and would not be completed before the expected date of March 20, 1997. At that time, it was anticipated

that the analyses would be completed and a supplemental LER would be submitted on July 31, 1997. On June 26, 1997, Engineering completed additional thermal hydraulic analyses evaluating the LPSW system two phase phenomena. These analyses further quantified waterhammer loads with the ACUs valved out. These analyses indicate that condensation induced waterhammers might occur in RBCUs with the ACUs valved out, but the magnitude of the predicted waterhammers was not severe and was not expected to affect pipe/system operability. The conclusions of these additional analyses continued to support operability of the RBCUs with the ACUs valved out.

However, the current mode of operation is not considered a permanent solution to this issue, due to the impact on the Reactor Building normal operating temperature. Therefore, Engineering is currently working on more detailed analyses. Additional analyses will be performed to determine what modifications or procedural restrictions would be required to return all ACUs to service. The results of these analyses will be used to determine the most appropriate long term solution to this issue.

In March 1998, Altran Corporation issued a technical report "Waterhammer Analysis of Reactor Building Cooling Units". Appendix E of this report determined that severe waterhammer might occur during a Loss Of Coolant Accident (LOCA) or Main Steam Line Break (MSLB) scenario if LPSW flow is initially isolated to the "B" RBCU with valve LPSW-566 closed. Valve LPSW-566 was full open on all three units at the time.

In a letter dated July 16, 1998, Altran Corporation identified additional situations where a severe waterhammer might occur. This might occur during a LOCA or MSLB scenario if LPSW flow is isolated to any RBCU, not just when valve LPSW-566 is closed.

An Oconee Engineering evaluation concluded that certain conditions might result in pipe breaks on the LPSW piping to the RBCUs. Engineering concluded that, with one or more RBCU Engineered Safeguards (ES) valves closed, the system would not be single

failure proof. The failure of a closed valve to automatically open upon ES actuation during a Loss Of Coolant Accident or Main Steam Line Break scenario might result in a significant waterhammer transient with a loss of containment integrity. Analysis indicated that waterhammer was more probable if the flow was throttled to less than 550 gpm. Further discussions between Engineering and Regulatory Compliance determined that there is no TS which addresses this scenario. Therefore, TS 3.0 should be entered if any RBCU LPSW isolation valves are closed or throttled to less than 550 gpm. Engineering advised the Operations Shift Manager that LPSW flow to RBCUs should be maintained higher than 550 gpm at all times.

On August 13, 1998, Engineering determined that, prior to issuance of the above guidance, one or more of the RBCU LPSW inlet isolation valves on each Oconee Unit have been isolated when performing maintenance or testing. If a motor operated RBCU inlet isolation valve is closed when a LOCA or MSLB is postulated to occur, there would be less than 550 gpm LPSW flow through the affected RBCU so that the line might be susceptible to waterhammer. Also, while closed for maintenance or testing, the ES actuated RBCU LPSW valves are subject to a single failure. If a single failure occurred, preventing the opening of the valves concurrent with the accident scenario, the postulated waterhammer might challenge containment integrity. This was reported to the NRC via the Emergency Notification System at 0943 hours.

Conclusion

The root cause of this event is determined to be Deficient Design Analysis, unanticipated interaction of systems. During the initial design of the Reactor Building Cooling Units in the early 1970s and the design of the modifications which added the Reactor Building Auxiliary Cooling Units (1979-1982), the waterhammer condition was not addressed. The analytical methods available at the time did not permit analysis of waterhammer in the detail necessary to reveal this problem. The current technology can better address

piping system thermal hydraulics and design for the prevention of waterhammer conditions.

This event is considered to be non-recurring. No corrective action can be taken to assure that industry operating experience, improving technology, testing methods, and/or analytical models do not reveal previously unknown unanticipated system interactions. Duke Power's Operating Experience Program is intended to assure evaluation of existing systems for the potential impact of industry experience on the current systems.

This event did not involve equipment failure and is not NPRDS reportable. There were no radiological overexposures, radioactive releases, or personnel injuries associated with this event.

CORRECTIVE ACTION:

Immediate:

1. The affected piping of the Reactor Building Auxiliary Cooling Units (ACU) was isolated and drained on all three Oconee units.

Subsequent:

1. Extensive analyses were initiated to better define and quantify the system interactions related to waterhammer in the LPSW piping to the RBCUs and ACUs.

2. Unit specific detailed analyses of the Unit 3 ACUs and associated piping have been completed and the ACUs were returned to service.

3. Following identification of the potential for severe waterhammers in the RBCU piping if initial flow is too low or valves are initially closed, Operations procedures were revised to limit RBCU flows. Additionally, the Inservice Test frequency for stroke testing the affected valves was revised from quarterly at power to cold shutdown.

Planned:

Revision 1 of this LER contained the following Planned Corrective Action which was identified as an NRC commitment:

> Complete analyses to return the Reactor Building Cooling System (RBCUs and ACUs) to service.

This corrective action is in progress and has been broken down into the following actions:

1. Unit specific analyses of Units 1 and 2 ACUs will be completed and the ACUs will be returned to service if warranted. (Unit 3 has already been addressed as stated in Subsequent Corrective Action 2 above.)

2. Duke Power is participating in the EPRI/Industry Collaborative Project to Support Resolution of GL 96-06 Waterhammer Issues. The intent of this participation is to assure that waterhammer and two phase flow issues have been adequately addressed.

Planned corrective action number 1 is considered to be an NRC Commitment Item. This is the only NRC Commitment item contained in this LER.

SAFETY ANALYSIS:

NRC Generic Letter 96-06 identified that cooling water systems serving the containment air coolers may be exposed to the hydrodynamic effects of waterhammer during either a Loss Of Coolant Accident (LOCA) or a Main Steam Line Break (MSLB).

The Engineering analysis at Oconee, for the NRC Generic Letter 96-06 concerns, indicated that the only scenarios leading to waterhammer in Reactor Building (RB) Cooling Units (RBCUs) require a high energy line break accident (LOCA or MSLB) with a concurrent Loss of Offsite Power (LOOP). The scenario where a high energy line break accident occurs concurrently with a Loss of Offsite Power (LOOP) has a very low probability accident sequence.

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If such an unlikely event were to occur, the Low Pressure Service Water (LPSW) pumps, the RBCU fans, and RB Auxiliary Cooling Unit (ACU) fans will temporarily lose power (an expected condition). The coast down time of the fans is longer than the coast down time of the pumps. The high temperature RB atmosphere will be forced across the RBCU and ACU cooling coils for a period of time with no forced LPSW flow through the coolers. The stagnant service water in the cooling coils may boil and create a substantial steam volume in the LPSW piping. As the LPSW pumps automatically restart, the pumped liquid may rapidly condense this steam volume and produce a waterhammer. The hydrodynamic loads introduced by such a waterhammer event might challenge the integrity and function of the LPSW system (especially the LPSW supply to, and return from, the B RBCU piping where the ACUs connect). The calculations to date indicate that it is less probable that damage would occur to either A or C RBCUs or associated piping with initial RBCU LPSW flow at normal flow rates.

The 1998 Altran Technical Report indicated that severe waterhammer might occur during a Loss Of Coolant Accident or Main Steam Line Break scenario if LPSW flow is initially isolated to a RBCU. The LPSW flow to RBCUs has been isolated when performing maintenance or quarterly stroke test of valves. If a LOCA or MSLB occurred while stroke testing and a single failure occurred in one of the Engineered Safeguards valves, a damaging waterhammer might occur.

If the waterhammer resulted in rupturing the LPSW piping, concerns would include loss of RB Containment Integrity, deboration of the RB Emergency Sump due to LPSW flow out the break, and decreased cooling capacity of the affected coolers. The Reactor Building Spray System (RBS) [EIIS:BE] also provides post accident containment cooling. One RBS train with two RBCUs can provide adequate containment heat removal. However, certain single failure modes exist that might prevent the combined systems from performing their required function in this scenario.

The RBCUs are currently operable with the Reactor Building Auxiliary Cooling Units (ACUs) drained and isolated for Units 1 and 2. The RBCUs for Unit 3 are currently operable with the RBCUs and ACUs in service. Units 1, 2, and 3 are currently restricted from stroke testing the Engineered Safeguards RBCU isolation valves except for cold shutdown conditions. When the analyses for Units 1 and 2 are completed it is expected that the RBCUs will be configured the same as Unit 3.

The health and safety of the public were not affected and there were no releases of radioactive material involved with this event.