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RLB-93-034

March 27, 1993

U.S. Nuclear Regulatory Commission
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Reference: Quad Cities Nuclear Power Station
Docket Number 50-254, DPR-29, Unit One

Enclosed is Licensee Event Report (LER) 92-023, Revision 01, for Quad Cities Nuclear Power Station.

This report is submitted in accordance with the requirements of the Code of Federal Regulations, Title 10, Part 50.73(a)(2)(v)(B) which requires the reporting of any event that could have prevented the fulfillment of the safety system to remove residual heat.

Respectfully,

COMMONWEALTH EDISON COMPANY
QUAD CITIES NUCLEAR POWER STATION

R. L. Bax
Station Manager

RLB/TB/as

Enclosure

cc: J. Schrage
T. Taylor
INPO Records Center
NRC Region III

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LICENSEE EVENT REPORT (LER)

Form Rev 2.0

Facility Name (1)	Docket Number (2)	Page (3)
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Title (4)

1B And 2B RHR Heat Exchangers Failed To Meet Design Heat Transfer Rate Requirement Due To Fouling and Silt Accumulation During Low Flow Rate Operation.

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 5 0 0 0
0 9	2 0	9 2	9 2	0 2 3	0 1	0 3	2 7	9 3		0 5 0 0 0

OPERATING MODE (9)	2	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10CFR (Check one or more of the following) (11)			
POWER LEVEL (10)	0 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)	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)
		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	
M. Ford	Ext. 2118	3 0 9	6 5 4 - 2 2 4 1

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)

ABSTRACT:

At 1625 hours on September 20, 1992, Unit One was in the REFUEL Mode in the cold condition. Technical Staff personnel performed heat transfer testing on the 1B Residual Heat Removal (RHR) heat exchanger. This testing determined that the heat transfer capability of the 1B RHR heat exchanger did not meet design requirements. At 2325 hours, on September 22, the 2B RHR heat exchanger was declared inoperable due to the previous testing results that indicated that the heat transfer rate was also below the design limit. On December 11, the 1A Hx was similarly determined to be below design.

The failure of the RHR heat exchangers to meet the design heat transfer rate was due to fouling and silt accumulation on the RHRSW side of the heat exchanger during low flow rate operation. The lower flow rate reduces the amount of turbulence, allowing settling out of silt on the tube inner surface.

Two RHRSW pump operation has been determined to provide adequate flushing. Routine two pump flushing will be performed for the RHR heat exchangers. This will insure the ability of the heat exchangers to perform their design function.

This report is being submitted in accordance with 10 CFR 50.73 (a)(2)(v)(B).

PLANT AND SYSTEM IDENTIFICATION:

General Electric - Boiling Water Reactor - 2511 MWt rated core thermal power.

EVENT IDENTIFICATION: 1B and 2B RHR Heat Exchangers Failed To Meet Design Heat Transfer Rate Requirement Due To Fouling And Silt Accumulation During Low Flow Rate Operation.

A. CONDITIONS PRIOR TO EVENT:

Unit: One Event Date: September 20, 1992 Event Time: 1625
Reactor Mode: 2 Mode Name: Refuel Power Level: 00%

This report was initiated by Deviation Report D-4-1-92-099

REFUEL Mode (2) - In this position interlocks are established so that one control rod only may be withdrawn when flux amplifiers are set at the proper sensitivity level and the refueling crane is not over the reactor. Also, the trip from the turbine control valves, turbine stop valves, main steam isolation valves, and condenser vacuum are bypassed. If the refueling crane is over the reactor, all rods must be fully inserted and none can be withdrawn.

B. DESCRIPTION OF EVENT:

At 1625 hours on September 20, 1992, Unit One was in the REFUEL Mode in the cold condition. Technical Staff personnel performed heat transfer testing on the 1B Residual Heat Removal (RHR) [BO] heat exchanger [HX].

On September 20, at 1100 hours, the 1B RHR heat exchanger thermodynamic capability test had been initiated in accordance with the station commitment to Generic Letter (GL) 89-13, 'Fouling of Safety Related Service Water Systems'. This test operated the RHR system in the Torus Cooling Mode, with one RHR and one RHR Service Water (RHRSW) pump [P] in operation. Data was collected for one hour. Data reduction determined that the 1B heat exchanger had a heat transfer rate coefficient of 146 Btu/hr-ft^2 -^{o}F. The passing criteria for the heat exchanger to perform it's design base heat removal required a heat transfer rate coefficient of at least 237 Btu/hr-ft^2-^{o}F. The as-found condition was 47 percent below the design margin.

This degradation to the Containment Cooling mode of RHR constituted a 4-hour non-emergency notification per 10CFR50.72(b)(2)(i), for a system or component found degraded during shutdown that would have placed the system in a limited condition of operation. The Emergency Notification System (ENS) call was made at 1747 hours.

Station Management and Technical Staff personnel decided to perform further testing on the 1B heat exchanger to investigate the effect flow rate has on fouling, and to verify the accuracy of the engineering equations to predict design base heat exchanger performance. It was decided to perform the second test in three steps. The first was to repeat the one RHR and one RHRSW pump test for 15 minutes, as base line data. The second step was to start a second RHRSW pump to increase the flow rate to near design. Data collected for 15 minutes in this "one and two" configuration would indicate the effectiveness of flushing. The third phase of the test was to shutdown the second RHRSW pump to return the system to the "one and one" configuration, and collect data for another 15 minutes. If the calculations were adequate, the data collected during the second "one and one" test would produce similar results as for the two pump flush.

On September 21, at 1546 hours, the second test on the 1B RHR heat exchanger was initiated. This test determined that during the two RHRSW pump operation, flushing action did occur. During the 15 minute flush the heat transfer rate reached 246 Btu/hr-ft^2-^{O}F, a 3 percent margin over design, and was continuing to trend up. The following "one and one" pump operation did produce similar results as the "one and two" phase, with a steady heat transfer rate of 233 Btu/hr-ft^2-^{O}F. Although this was slightly lower than the "one and two" phase, it did support the accuracy of the equations for testing at off design flow rates.

The determination that the engineering equations were accurate brought up an operability concern for the Unit Two RHR heat exchangers. During the previous Unit Two outage (Q2R11, January 1992) similar testing had been performed on the 2A and 2B RHR heat exchangers. The initial testing on the 2A heat exchanger had been performed in a "one and one" configuration. This test indicated that the heat exchangers failed to meet design. Failure of the 2A heat exchanger required expanding the testing to the 2B heat exchanger. Testing the 2B in a "one and one" configuration also indicated that it was unable to meet design requirements. These results were considered questionable, because previously, Unit One RHR heat exchanger testing (Q1R11) had passed with significant margin. The previous Unit One testing had been performed with two RHR and two RHRSW pumps in operation. It was decided in January of 1992 to re-perform the test on the 2A RHR heat exchanger in a similar "two and two" configuration. This re-test of the 2A heat exchanger during Q2R11 passed with approximately 30 percent margin. It was believed that the "one and one" test induced too great an error into the results due to one pump equations. Performing the test in a two pump configuration was closer to design and provided more accurate data. The 2A and 2B heat exchangers were considered operable. No event reports were initiated at that time, because it had been concluded that the test method inaccurately showed the Unit Two heat exchangers failed the acceptance criteria.

The determination in September of 1992 that the "one and one" pump tests were accurate for an as-found condition, and that two pump operation flushed the heat exchanger, required a re-evaluation of the previous Unit Two testing. This review determined that the 2B heat exchanger was possibly in a fouled condition.

At 2325 hours, on September 22, 1992, Unit Two was in the RUN Mode at 98 percent rated core thermal power. The 2B RHR heat exchanger was declared inoperable due to the previous testing results, which indicated that heat transfer rate was below the design limit. The 2B-loop of Containment Cooling was declared inoperable and QCOS 1000-10, Containment Cooling Outage Report, was entered, placing Unit Two in a seven day limiting condition of operation (LCO). Since the 2A heat exchanger had been tested with two pumps, it was considered to still be operable.

The station performed testing on the 2B heat exchanger to verify the as-found condition, measuring the heat transfer rate in the "one and one" configuration. The as-found test was followed with a two RHRSW pump flush. The as-found condition was approximately 45 percent below design, which confirmed the previous outage testing results. The following two pump flush was successful in restoring the 2B heat exchanger margin to 33 percent over design.

The 2A heat exchanger had previously been flushed with two pumps in January 1992. It was considered prudent that the heat transfer capabilities should be re-verified. On September 23, a similar "one and one" pump test was performed. This test determined that after nine months of operation the heat exchanger still had a seven percent margin. A two pump flush was performed to restore greater heat transfer. The flush provided the 2A heat exchanger a 30 percent margin.

On December 11, 1992, at 1940 hours, a one and one test was performed on the 1A RHR heat exchanger to determine heat transfer ability. This test determined that the as-found status was 32 percent degraded. The 1A heat exchanger was then flushed using two RHRSW pumps to restore design margin.

At 2100 hours, the 1A RHR heat exchanger was retested in the one and one configuration to determine the effectiveness of the flush. The flush had improved the efficiency, but the heat exchanger was still 17 percent below the design limit.

The 1A RHR heat exchanger was flushed two more times, and retested after each flush. Each flush improved the heat transfer efficiency slightly. However, the heat exchanger was still seven percent below the design limit. At this time the temperature in the Torus, which was the heat source for the test, had decreased to a point which prohibited further testing.

After Unit One start-up from the Refueling outage, high pressure steam system testing increased the Torus temperature. The operating department performed an extended two pump flush of the 1A heat exchanger for approximately eight hours. On December 16, at 1130 hours, the 1A RHR heat exchanger was retested. The results of the extended two pump flush determined that no extra margin had been achieved. The heat exchanger remained seven percent degraded. However, the 1A heat exchanger was considered operable under the operability assessment evaluation conditions.

At the conclusion of this testing, all RHR heat exchangers have been tested and shown to be operable. On September 21 through 23, the 1B, 2B and 2A heat exchangers were flushed and determined to have margin in excess of the design requirements. On December 16, the 1A heat exchanger was last tested, the as-left status was slightly below the design limits, yet operable under the limits of the operability assessment.

C. APPARENT CAUSE OF EVENT:

This report is being submitted in accordance with the requirements of the Code of Federal Regulations, Title 10, Part 50.73(a)(2)(v)(B) which requires the reporting of any event that could have prevented the fulfillment of the safety system to remove residual heat.

The failure of the RHR heat exchangers to meet the design heat transfer rate was due to fouling on the RHRSW side of the heat exchanger. The tubes were fouled with soft silt, that forms on the inner surface of the tubes during periods while the system is not in operation. Testing results determined that operation of the RHRSW system with only one pump produces insufficient flow to remove fouling. This fouling resulted in the heat exchangers being greater than 30 percent below the design margin.

Normal system operation requires only one RHRSW pump to perform required heat removal. During one pump system operation the lower flow produces a lower amount of turbulence as the water passes through the tubes. This results in a settling out of silt on the tube [TBG] inner surface. During testing, the two pump operation increased the flow rate, resulting in higher turbulence. This flushing action reduced the silt layer allowing the heat exchanger to meet design limits.

A visual inspection of the RHRSW side of the 1B RHR heat exchanger was performed to document the condition of the tubes. This inspection was performed following the heat exchanger testing. The inspection found minor silt accumulation on tubes. There appeared to be no build-up of hard scaling. No tubes were found to be blocked during the visual inspection. The tubes and tube-sheet were in good condition with no signs of pitting.

The failure of the 1A heat exchanger to meet design heat transfer requirements after extended flushing may be due to either a hard deposit fouling the tube walls or short circuiting of the flow past the heat exchanger. A physical inspection will be performed to determine the exact cause.

Testing over December 31, 1992 to January 14, 1993 was performed to determine the effect of sustained one pump operation. The 2A RHR heat exchanger had one RHRSW pump in continuous operation for two weeks. Three tests were performed over this period. A as-found baseline test, a one week test, and a second week test were performed. The results from this testing varied from -10% margin baseline to 1% margin after one week to -6% at the end of two weeks. Although this data varied, it indicated that continuous operation with only one RHRSW pump does not result in additional fouling. Following this testing the heat exchanger was flushed to restore 17% margin.

D. SAFETY ANALYSIS OF EVENT:

The safety consequences of this event were minimal. The 1B RHR heat exchanger was still capable of removing heat from the containment while in the fouled condition. If additional cooling were required a second pump could be started. Starting of the second pump would provide greater heat removal, and perform a flushing action. The Containment Cooling mode of the RHR system has two separate loops either of which can be operated to remove heat from the Primary Containment during normal and accident conditions.

The RHR heat exchanger is designed for maximum flow rates commensurate with two RHR and two RHRSW pump operation. During routine operation of the heat exchangers, heat removal capacity has always been greater than required. Conservatism in design heat removal rates is believed to be providing this greater margin.

On December 14, 1992, the Nuclear Engineering Department completed an operability assessment which determined that at or below a river temperature of 88.7 degrees, the RHR heat exchangers could be 17 percent degraded and still perform their design safety function. 88.7 degrees is the highest river temperature recorded over the stations history. The design base accident assumes a river temperature of 95 degrees. At the lower river temperature, the 2A heat exchanger is capable of performing its design safety function.

E. CORRECTIVE ACTIONS:

The immediate corrective action was to declare the 1B RHR heat exchanger inoperable and make the required notifications. Upon determination that the engineering equations were accurate and the second "one and one" pump test was indicating inadequate design margin, the 2B RHR heat exchanger was declared inoperable.

Further testing on the 1B, and 2A and 2B heat exchangers determined that two RHRSW pump operation for a period of 30 minutes is sufficient to flush the heat exchanger, and provides a margin of approximately 30 percent beyond the design minimum.

The second test on the 1B RHR heat exchanger provided a minimal flush, such that it was able to meet the design requirements, yet had little excess margin. To insure that there is sufficient margin, an additional two pump flush was performed prior to Unit One start-up (NTS# 2542009209901).

As data indicates that the effectiveness of a two pump flush provides enough margin to operate for nine months, a routine nine month flushing schedule will be performed for the RHR heat exchangers. This will insure the ability of the heat exchangers to perform their design function (NTS# 2542009209903).

To provide greater understanding of fouling rate, one heat exchanger will be selected to have a thermodynamic test performed every three months. As this heat exchanger will have quarterly testing performed on it, it may be determined that it does not require the routine nine month flush. Data from this testing will ultimately determine the required flushing frequency for all the RHR heat exchangers. Final determination of a flushing schedule will be completed by June 1993 (NTS# 2542009209904).

A Station procedure to direct operation of two RHRSW pumps has been initiated. This will allow an operator to initiate a higher flow rate to flush the heat exchanger, if inadequate heat removal is detected (NTS# 2542009209905).

The inability to flush the 1A heat exchanger indicates that it has a different mode of degradation. Work request Q04879 was initiated to perform an inspection of the separation baffle plate and tube surfaces. This activity is presently in the short outage schedule. Work request Q04758 has been written to perform required repairs or cleaning as determined during the inspection. Final repairs will be performed during the next refuel outage, Q1R13, May 1994 (NTS# 2542009209906).

These actions will insure that the RHR heat exchangers are capable of performing their design base safety function at all times.

F. PREVIOUS EVENTS:

As heat exchanger thermodynamic testing has not been performed prior to the implementation of Generic Letter 89-13, no previous events document failure of the RHR heat exchangers. Generic Letter 89-13 was initiated due to an industry wide concern for fouling of safety related service water systems.

Two licensee Event Reports (LER) have been written documenting failure of the Emergency Containment Cooling System (ECCS) room coolers due to fouling. LER 92-007 documents inspection results that found both Unit Two RHR corner room coolers fouled in excess of their design margin. LER 92-008 reports similar fouling of the Unit One RHR room cooler beyond their design margin.

Both events were due to gradual accumulation of silt and debris over a period of greater than ten years. The corrective action for these events was to perform regular inspections and cleaning per the station commitment to G.L. 89-13.

G. COMPONENT FAILURE DATA:

The RHR heat exchangers were manufactured by Southwestern Engineering Company, purchased and installed by General Electric.