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July 13, 2001

United States Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Operating Licenses DPR-58 and DPR-74
Docket Nos. 50-315 and 50-316

Document Control Manager:

In accordance with the criteria established by 10 CFR 50.73 entitled Licensee Event Report System, the following report is being submitted:

LER 315/99-008-01: "Residual Heat Removal (RHR) Piping Vibration Could Potentially Cause RHR Piping Failures"

The following commitment was identified in this submittal:

- A final design change to resolve the system vibration will be implemented by the end of the next refueling outage for Unit 1 and by the end of cycle 14 for Unit 2.

Should you have any questions regarding this correspondence, please contact Mr. Ronald W. Gaston, Manager, Regulatory Affairs, at 616/697-5020.

Sincerely,

J Molden for

Joseph E. Pollock
Plant Manager

/inj
Attachment

IE22

c: J. E. Dyer, Region III
A. C. Bakken
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NRC Resident Inspector
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NRC Form 366 (6-1998) U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

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

APPROVED BY OMB NO. 3150-0104 EXPIRES 06/30/2001

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS MANDATORY INFORMATION COLLECTION REQUEST: 50.0 HRS. REPORTED LESSONS LEARNED ARE INCORPORATED INTO THE LICENSING PROCESS AND FED BACK TO INDUSTRY. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (T-6 F33), 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

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TITLE (4)

Residual Heat Removal (RHR) Piping Vibrations Could Potentially Cause RHR Piping Failures

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
1	15	1999	1999	--	008	--	01	7	13	2001	Cook Unit 2	05000-316
											FACILITY NAME	DOCKET NUMBER

OPERATING MODE (9)	5	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)					
POWER LEVEL (10)	00	20.2201 (b)	20.2203(a)(2)(v)		50.73(a)(2)(i)		50.73(a)(2)(viii)
		20.2203(a)(1)	20.2203(a)(3)(i)	X	50.73(a)(2)(ii)		50.73(a)(2)(x)
		20.2203(a)(2)(i)	20.2203(a)(3)(ii)		50.73(a)(2)(iii)		73.71
		20.2203(a)(2)(ii)	20.2203(a)(4)		50.73(a)(2)(iv)		OTHER
		20.2203(a)(2)(iii)	50.36(c)(1)		50.73(a)(2)(v)		Specify in Abstract below or n NRC Form 366A
		20.2203(a)(2)(iv)	50.36(c)(2)		50.73(a)(2)(vii)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
I.N. Jackiw, Compliance Engineer	616/465-5901, X1602

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX

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)

This LER is being issued to provide the results of the root cause analysis and replaces the original LER in its entirety.

On January 15, 1999, with both units in Mode 5, plant operators reported excessive piping vibration in the residual heat removal (RHR) rooms. Since initial plant operation, noise and vibration has been known to occur in both the Unit 1 and Unit 2 RHR systems while the systems operated in shutdown cooling with low decay heat, a depressurized reactor coolant system (RCS), and low RCS temperature. On March 10, 1999, an ENS notification was made to the NRC in accordance with 10 CFR 50.72(b)(2)(i), for any condition, found while the reactor was shutdown, that had it been found while the plant was operating, would have resulted in the plant being in an unanalyzed condition. As such, LER 50-315/99-008 was submitted in accordance with 50.73(a)(2)(ii)(A), for the plant being in an unanalyzed condition.

The source of excessive vibration in the RHR system was caused by cavitation across the RHR flow control valves. This cavitation was due to excessive pressure drops across the control valves under certain relatively low flow conditions when the RHR system flow was throttled and pumping into a depressurized reactor vessel. The primary cause of failures in the tieback structures (originally installed to control vibration of the branch lines) was inadequate design. The design process failed to account for the thermal stress and loading conditions on the tieback structures.

Excessive RHR system vibration occurs under specific flow conditions where the RHR system is being throttled and when the normal cooldown path is used. However, under an accident scenario, flow is not throttled and the injection path is utilized. Therefore, the conditions for vibration would not occur during accident operation. Corrective actions have been taken to reduce the susceptibility of the RHR system to excessive vibration. The RHR system was monitored during system testing and operation to verify the effectiveness of these corrective actions. A final design change to resolve the system vibration will be implemented by the end of the next refueling outage for Unit 1 and by the end of cycle 14 for Unit 2.

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TEXT *(If more space is required, use additional copies of NRC Form (366A)* **(17)**

Conditions Prior to Event
Unit 1 was in Mode 5, Cold Shutdown
Unit 2 was in Mode 5, Cold Shutdown

Description of Event
On January 15, 1999, with both units in Mode 5, plant operators reported excessive piping vibration in the residual heat removal (RHR) rooms. The vibration occurred while operating the RHR systems in the shutdown cooling mode with low decay heat, a depressurized reactor coolant system (RCS), and low RCS temperature. Although the systems were determined to be operable, an engineering evaluation was initiated to determine the cause of the vibration. An ENS notification was made to the NRC in accordance with 10 CFR 50.72(b)(2)(i), for any condition, found while the reactor was shutdown, that had it been found while the plant was operating, would have resulted in the plant being in an unanalyzed condition. As such, LER 50-315/99-008 was submitted in accordance with 50.73(a)(2)(ii)(A), for the plant being in an unanalyzed condition.

Noise and vibration had been known to occur in both the Unit 1 and Unit 2 RHR systems since the initiation of plant operation. As a result, the systems experienced repeated occurrences of weld failures in small branch lines off the main RHR headers. In more recent years, weld failures have also been seen in the "tieback" support structures that were installed to reduce vibration of these branch lines. In 1992, a task force, organized to investigate and determine the root cause of these weld failures, concluded that the weld failures were attributed to high frequency, low amplitude fatigue generated by flow induced vibration. The corrective actions from the 1992 investigation focused on installation of additional supports to reduce cyclic stress and the development of a program for a periodic examination of the RHR system branch line welds.

In January 1999, I&M performed additional analysis of the RHR system flow characteristics in order to address continuing vibration-related problems. Data was collected while the RHR system was operated using both the normal cooldown flowpath and the injection flowpath. The RHR system flow data was used to evaluate the significance of the vibration and to determine the cause of the tieback failures. Excessive noise and vibration were noted when the RHR system was operated using the normal cooldown flowpath. However, a significant reduction in vibration was noted when the RHR system was operated using the injection flowpath.

Cause of Event
The excessive vibration in the RHR system was caused by cavitation at certain flow conditions. Evidence of cavitation was identified at IRV-310 and IRV-320, the RHR Heat Exchanger Flow Control Valves, and at IRV-311, the RHR Heat Exchanger Bypass Flow Control Valve. This cavitation was due to excessive pressure drop across the control valves under certain relatively low flow conditions; specifically, when the RHR system flow was throttled and pumping into a depressurized reactor vessel.

Vibration of the RHR piping has led to fatigue failures in instrument branch lines, primarily at tubing connections. Cavitation at the control valves has been identified as the source of energy that caused branch line welds to fail. The cause of failures in the tieback structures (originally installed to control vibration of the branch lines) was determined to be inadequate design that failed to account for thermal stress and a failure to properly address the loading conditions.

An investigation initiated using pump vibration measurements, field observations, equipment failure analysis, analytical engineering models, and other root cause processes identified the following causal factors:

Cavitation at the control valves - The source of excessive vibration in the RHR System during Mode 5 was attributed to the original design that caused cavitation at certain flow conditions. Evidence of cavitation was identified at control valves IRV-310, IRV-311, and IRV-320 and was due to excessive pressure drop across the control valves under certain flow

conditions. Specifically, under these conditions, evidence of cavitation (in the form of excessive vibration) was observed at various flows when utilizing the normal cooldown flowpath and when the RHR system flow was throttled and pumping into a depressurized reactor vessel. Under the same conditions, evidence of cavitation was seen when utilizing the injection flowpath with the flow rate at or below 2900 gpm.

Ineffective past design control - The cause for the branch line weld failures was attributed to fatigue caused by sustained cavitation at the control valves. Past corrective actions for the weld cracking issues were ineffective and failed to address the vibration issue. Additionally, the cause of failures in the tieback structures was attributed to technical errors in the design of the tieback support structures. The original tieback structure design did not consider the thermal stresses and did not properly address the loading conditions. Because of errors in their design, some tiebacks also caused localized overstresses in the piping system.

Analysis of Event

The dominating source of excessive noise and vibration in the RHR system was caused by cavitation at the control valves when utilizing the normal cooldown flowpath. Evidence of cavitation was also seen at the control valves using the injection flowpath when flow was throttled below 2900 gpm. The flowrate of 2900 gpm was determined based on field observations of vibration and noise at this flow. As the injection path flowrate was increased (up to approximately 3200 gpm) the noise and vibration were observed to drop substantially. Analytical evaluation of cavitation indices at the flow control valves, at various flow rates, yielded results which support and are consistent with the field observations.

An investigation determined that the "excessive" vibration identified in the RHR system occurs under specific flow conditions where the RHR system is being throttled and is most prevalent when the normal cooldown flowpath is used. However, under an accident scenario, flow is not throttled and the injection flowpath is utilized. Therefore, the conditions for vibration will not occur during accident operation. For normal operation the RHR System Operation Procedures have been modified to preclude or minimize the susceptibility of system vibration.

Evaluations conducted relative to the significance of the tieback failures, due to both thermal stress and vibration loading, determined that the ability of the RHR system to perform its safety related function would not be affected by the tieback failures. The tieback failures have consisted of weld failures within the tieback structures. These failures within the tieback structures have not caused a failure of the RHR shutdown cooling flowpaths. Regarding the RHR system branch lines, the potential existed for fatigue damage to occur to the branch lines from periods of operation while the system vibration was occurring. In general, the branch lines are small thus reducing the potential magnitude of any leakage. The most prone area for development of leakage due to this damage was determined to be at the tubing connection to the root valves. Leakage in this area could be terminated by closing the root valves. Liquid penetrant testing of instrument valve/tubing weld interfaces was completed in the field and no defects were identified. It was noted that there was a low likelihood of vibration induced leakage under accident conditions since the conditions are such that cavitation is precluded.

Corrective Actions

The operation of the RHR system was changed to use the injection flowpath as the preferred flowpath. D.C.Cook performed an operability determination evaluation that provides direction for the use of the RHR injection flowpath for all modes of operation as an alternative to the normal cooldown flowpath. Procedure revisions have been implemented to ensure long term RHR system flow rates will be kept in excess of approximately 2900 gpm to prevent cavitation. A design change has been installed to modify tieback supports that could pose design basis stress concerns and/or have internal thermal problems. The RHR system was monitored during system testing and operation to verify the effectiveness of the corrective actions. A final design change to resolve the system vibration will be implemented by the end of the next refueling outage for Unit 1 and by the end of Cycle 14 for Unit 2.

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TEXT *(If more space is required, use additional copies of NRC Form (366A)* **(17)**

The corrective actions to prevent recurrence for the root cause regarding generic legacy problems in the design control process were previously evaluated under the Donald C. Cook Corrective Action Program. The root cause evaluation identified numerous corrective actions to address management, organizational, and programmatic issues in the Engineering organization. These actions were reviewed by the NRC under the Manual Chapter 0350 Process and deemed acceptable.

Previous Similar Events

There have been numerous LERs from 1999 and 2000 that have been linked to the design control inadequacies root cause. Since the condition described here is historical, the corrective actions from these LERs would not have identified or prevented this condition.