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February 8, 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 revised report is being submitted:

LER 315/99-013-01, "Safety Injection and Centrifugal Charging Throttle Valve Cavitation during LOCA Could Lead to ECCS Pump Failure."

This LER supplement is being submitted to include information from the completed root cause evaluation. Vertical lines in the right margin identify revised or supplementary information.

No new commitments were identified in this submittal.

Should you have any questions regarding this correspondence, please contact Mr. Ronald W. Gaston, Manager Regulatory Affairs, at (616) 465-5901, extension 1366.

Sincerely,

Joseph E. Pollock
Plant Manager

/bwo
Attachment

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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

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
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TITLE (4)

Safety Injection and Centrifugal Charging Throttle Valve Cavitation During LOCA Could Lead to ECCS Pump Failure

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
											D.C. Cook, Unit 2	05000-316
03	27	1999	1999	--	013	--	01	02	08	2001	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)	0%	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)	X	50.73(a)(2)(v)	Specify in Abstract below or in 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)
Brenda W. O'Rourke, Compliance Engineer	(616) 465-5901, x2604

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)

On March 27, 1999, during development of an Emergency Core Cooling System (ECCS) thermal hydraulic flow analysis model, Engineering concluded that preliminary hydraulic flow analysis results indicated that the Unit 1 Safety Injection (SI) and Centrifugal Charging (CC) throttle valves could potentially experience cavitation during a Loss of Coolant Accident (LOCA). Cavitation-induced erosion could lead to a pump runout condition and subsequent failure of the ECCS pumps. The analysis also identified that the throttle valves were less open than previously determined. LOCA generated debris could potentially clog the throttle valve, resulting in reduced cooling flow to the reactor core. On May 4, 1999, a 4-hour notification was made to the NRC in accordance with 10CFR50.72(b)(2)(i) for the plant being in an unanalyzed condition, and 10 CFR 50.72(b)(2)(iii)(D) for any event or condition that alone could have prevented the fulfillment a safety function. Similar conditions also exist for the Unit 2 SI and CC throttle valves. Information regarding safety significance and corrective/preventive actions is being provided in this LER supplement based on completion of the root cause evaluation. The cause for this condition is inadequate original design application of the SI and CC throttle valves. Opportunities to identify this condition were missed during previous evaluations of industry events and regulatory and vendor information. This condition has minimal safety significance because the likelihood of design basis debris being transported to the CC throttle valves is low based on the potential for detrimental debris to flow such a distance at the available flow rates. In the event the CC throttle valves become clogged, the SI and RHR pumps are still available for long-term core cooling following a LOCA.

The Unit 1 and Unit 2 SI and CC system throttle valves were replaced with a different valve design. An extent of condition evaluation was performed to identify other systems that utilize manual throttle valves that are subjected to large pressure drops over a long period of operation. No other valves operating under similar conditions were identified as susceptible to cavitation-induced erosion or potential clogging under LOCA conditions.

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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 March 27, 1999, during development of an Emergency Core Cooling System (ECCS) thermal hydraulic flow analysis model, Engineering concluded that preliminary hydraulic flow analysis results indicated that the Unit 1 Safety Injection (SI)(EIIS:BQ) and Centrifugal Charging (CC)(EIIS:SJ) throttle valves (EIIS:FCV) could potentially experience cavitation during a LOCA. Due to the large differential pressures created across the SI and CC throttle valves during a Loss of Coolant Accident (LOCA), cavitation and possible mechanical erosion of the valves and downstream piping could occur. Throttle valve erosion during post-LOCA conditions could cause the valves to allow excess flow through the SI and CC pumps (EIIS:P), resulting in a pump runout condition and subsequent failure of the ECCS pumps to perform their intended safety function.

The flow analysis also predicted that the SI and CC throttle valve plug positions were less open than previously determined by calculation. On April 8, 1999, radiography was performed on the two SI throttle valves to better assess their positions. Radiography results identified that the as-found positions of the throttle valves closed further than predicted by the preliminary hydraulic analysis, and indications of possible valve erosion were present. With the throttle valves found further closed than expected, debris generated in containment during a LOCA could potentially become lodged in the throttle valves, during the recirculation phase of a LOCA, thus reducing the amount of flow to the reactor core. Similar conditions also exist for the Unit 2 SI and CC throttle valves.

Based on the results of the preliminary flow analysis, on May 4, 1999, a 4-hour notification was made to the NRC in accordance with 10 CFR 50.72(b)(2)(i) for a condition that resulted in the plant being in an unanalyzed condition, and 10 CFR 50.72(b)(2)(iii)(D) for any event or condition that alone could have prevented the fulfillment of a system safety function needed to mitigate the consequences of an accident. On June 4, 1999, LER 50-315/99-013-00 was submitted to the NRC in accordance with the requirements of 10 CFR 50.73(a)(2)(ii)(A) and (a)(2)(v)(D).

Information regarding safety significance and corrective/preventive actions is being provided in this LER supplement based on completion of the root cause evaluation.

Cause of Event
The cause for this condition is inadequate original design application of the SI and CC throttle valves. Specifically, during the initial design of the SI and CC systems the valves were not adequately evaluated for susceptibility to cavitation erosion under LOCA conditions. In addition, the throttle valves' plug position and associated flow passage were not evaluated for potential clogging with debris from the containment recirculation sump.

Opportunities to identify this potential condition were missed during previous evaluations of industry events and regulatory and vendor information regarding the potential for post-LOCA ECCS pump runout damage due to cavitation-induced throttle valve degradation.

Analysis of Event
UFSAR Section 6.2 states that the primary function of the ECCS is to provide cooling water to the reactor core in the event of a LOCA. The ECCS system consists of six ECCS pumps: two Centrifugal Charging pumps, two Residual Heat Removal (RHR) pumps, and two Safety Injections pumps. The subject throttle valves are installed on each of the four CC pump lines to the reactor coolant loops and on the discharge side of each SI pump.

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

The operation of the ECCS following a LOCA consists of two distinct phases: 1) the injection phase during which reactivity is controlled, initial cooling of the core is accomplished, and coolant lost from the primary system is replenished, and 2) the recirculation phase, in which long term core cooling is provided during the accident recovery period. Long term core cooling is provided, in part, by the SI and CC systems which deliver coolant water from the containment recirculation sump back to the reactor coolant system. Following a LOCA event, any debris generated in containment would be filtered through a 0.25-inch square mesh screen (EIIS: BP, SCN) prior to entering the containment sump to prevent foreign material from entering the ECCS system.

The subject SI and CC throttle valves are provided in the injection paths for the SI and CC pumps to balance flow and to provide resistance in the ECCS pipe lines to limit flow such that pump run-out does not occur. In the event of a LOCA, a large differential pressure develops across the throttle valves as the reactor coolant system pressure drops. During this initial pressure drop and under long-term operation (post-LOCA recirculation), valve cavitation and mechanical erosion could occur. This is due to the design of Donald C. Cook Nuclear Plant's (CNP's) SI and CC throttle valves, which required the valves' plugs to be positioned further closed in order to achieve the required system flow balance, and the unique configuration of the system piping.

Internal inspections of the Unit 1 and Unit 2 SI and CC throttle valves and downstream system piping were performed to determine the as-found valve plug position and whether any degradation of the valves or nearby piping was present. The Unit 2 inspections identified that two of the six valves exhibited slight indications of cavitation at the valve plug or near the outlet of the valve. Indications of cavitation in downstream piping were considered negligible because of the lack of any significant material loss as compared to the material that sustained no damage. To evaluate the potential for the SI and CC valves to become clogged, ball bearings were inserted into the valve bodies to determine whether such material could pass through the valve without clogging. Neither of the four CC throttle valves could pass the smallest (0.156-inch) gauge ball. The two SI throttle valves passed the largest (0.375-inch) gauge balls freely. Based on these results, the CC throttle valves could become clogged should design basis debris (0.265-inch) reach the valve during the recirculation phase of a LOCA. Similar results were identified during the Unit 1 inspections.

Although the ECCS injection lines and associated components (e.g., throttle valves) are required to pass all debris that could pass through the containment sump screen, the debris most likely to result in throttle valve clogging is the heavier, more rigid debris (such as insulation jacketing) that could be transported to the containment sump during a LOCA. However, the likelihood of this type of material reaching the throttle valves is very low. This conclusion is based on:

- A 0.25-inch containment sump screen which limits the size of the debris that can be transported to the ECCS pumps.

- Low containment water transport velocities which preclude the transport of containment debris to the sump.

- Containment sump and ECCS suction piping design - the containment sump design is such that the flow entering the ECCS suction piping has to undergo several directional changes as it clears the crane wall and enters the ECCS suction piping. These directional changes promote the dropout of debris in the areas of low velocity. However, buoyant/neutral density particles have a greater potential to travel to the injection lines, but are typically soft in nature and therefore less likely to cause clogging of the throttle valves.

- Containment sump versus ECCS pump elevation differential - the elevation differences make it more difficult for heavier debris to traverse the vertical distance from the containment sump to the suction of the ECCS pumps.

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Westinghouse letter Nuclear Safety Advisory Letter (NSAL) 96-001, "Erosion of Globe Valves in ECCS Throttling Applications," evaluated the impact of the subject condition on plant operation during a small break LOCA, a large break LOCA, and during the hot leg recirculation phase of a LOCA. The NSAL indicated that valve erosion might occur during a LOCA as a result of high pressure drops across the valves. Consequently, the high head ECCS pumps (i.e., SI and CC pumps) could experience a runout condition that may require operator action to terminate operation of the pumps. While the pumps may not remain operable for 100 days post-LOCA (as assumed in CNP's accident analysis), the evaluation concludes that the SI and CC pumps should remain operable long enough to perform their intended safety function.

In conclusion, although the CC throttle valves could potentially become clogged with design basis debris, the likelihood of such debris being transported to the CC throttle valves is low. However, should this condition occur, the SI and RHR pumps are still available for long term core cooling following a LOCA. As such, this condition has minimal safety significance.

Corrective Actions

The Unit 1 and Unit 2 SI and CC system throttle valves were replaced with a different valve design. The new valve design has an external position-indicating device so that the valve plug position can be determined. In addition, flow orifices were installed in the SI and CC system piping near the throttle valves to reduce the differential pressures across the valves. The flow orifices are sized such that the throttle valves can be sufficiently open to meet accident flow requirements and allow design basis debris to pass through the valves without clogging. The results of post-modification testing and ECCS flow balance testing identified no audible cavitation-induced noise or vibration.

An extent of condition evaluation was performed to identify other systems that utilize manual throttle valves that are subjected to large pressure drops over a long period of operation. No other valves operating under similar conditions and configuration were identified as susceptible to cavitation-induced erosion or potential clogging under LOCA conditions.

As part of the Unit 2 Restart effort, system and programmatic assessments were performed during the Expanded System Readiness Reviews to reestablish and document the plant's design and licensing basis. Based on identified programmatic weaknesses in the control of CNP's design and licensing basis, an Engineering Leadership Plan was implemented which established a design basis authority and a new design control process that encompasses design verification, vendor technical information, and design specifications. In addition, a new operating experience program was established to ensure industry issues are adequately addressed for applicability to CNP. These plans, in whole, will help to preclude similar events from occurring.

Previous Similar Events

No previous LERs were identified that specifically address cavitation-induced erosion of throttle valves. However, there have been previously docketed LERs associated with inadequate design review process. Since the condition described here is historical, the corrective actions from these LERs would not have identified or prevented this condition.

LER 50-315/99-031-01: "Valves Required to Operate Post-Accident Could Fail to Open Due to Pressure Locking/Thermal Binding" - Identified valves in the suction path from the containment recirculation sump to the ECCS pumps that were susceptible to pressure locking/thermal-binding (PL/TB) following a LOCA. The cause was inadequate system design. Specifically, the failure to consider the effects of PL/TB during the initial design process and to identify and correct the initial design errors during subsequent design review activities.