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AEP
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MICHIGAN
POWER

October 18, 2000

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 316/98-049-01, "Emergency Boron Injection Flow Path Inoperable Due To Original Design Deficiencies."

The following commitment was identified in the submittal:

- CNP will modify the Unit 1 BAST boric acid concentrations and system flow conditions prior to restart.

Should you have any questions regarding this correspondence, please contact Mr. Wayne J. Kropp, Director Regulatory Affairs, at 616/697-5056.

Sincerely,

A. Christopher Bakken, III
Site Vice President

/ram
Attachment

c: J. E. Dyer, Region III
D. Hahn
B. A. McIntyre
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R. P. Powers
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NRC Resident Inspector
Records Center, INPO

IE22

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)

Emergency Boron Injection Flow Path Inoperable Due To Original Design Deficiencies

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 Cook Plant Unit 2	DOCKET NUMBER 05000-316
10	20	1998	1998	--	049	-- 01	10	18	2000	FACILITY NAME	DOCKET NUMBER

OPERATING MODE (9)	5	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)							
			20.2201 (b)		20.2203(a)(2)(v)	X	50.73(a)(2)(i)		50.73(a)(2)(viii)
POWER LEVEL (10)	000		20.2203(a)(1)		20.2203(a)(3)(i)		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 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)
R. A. Meister, Regulatory Affairs	616 / 465-5901, x1707

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 October 20, 1998, with both units in MODE 5, "Cold Shutdown," it was determined that the design of the Donald C. Cook Nuclear Plant (CNP) emergency boron injection system was inadequate. Specifically, the system as designed/built could have: 1) had the potential for exposing the reactor coolant pump seals to boric acid concentrations above their design limits, 2) led to system flow deviations (due to boron precipitating out of solution), or 3) resulted in a failure to maintain the necessary minimum net positive suction head for the boric acid transfer pumps.

The apparent cause of the event has been attributed to errors in the original design of the boric acid make-up system. The individuals who designed the system apparently failed to validate all of the assumptions when the design of the system was developed.

To address the concerns discussed above design modifications were implemented to reduce the boric acid concentration in boric acid storage tank and adjust system flow rates to ensure the pump net positive suction head NPSH requirements are met. Additionally, Restart Action Plan 3A, "Inadequate Design Control," implemented a number of programmatic enhancements to the CNP design process.

Based on past operating history, it has been concluded that the emergency boration system would have performed adequately and that no actual reduction in the margin of safety afforded to the public occurred.

This supplement is issued to provide the root cause and corrective actions for the documented noncompliance and replaces Licensee Event Report 50-315/1998-049-00 in its entirety.

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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

A review of the emergency boration system design limits revealed a number of concerns. Each concern is discussed below.

Charging Header Boric Acid Concentration Concerns:

Although 75 gallons a minute (gpm) was the original flow expectation for the emergency boration system, the results of delivering concentrated boric acid at a higher rate than would have matched the charging flow rate was not fully considered when designing the system. The following two concerns were identified with delivering an excessive amount of boric acid to the suction of the charging pump.

1. A vendor letter for the reactor coolant pump seals dated March 21, 1998, requires the seal water injection temperature to be less than 150 degrees fahrenheit (F) and the injected boric acid concentration to be less than 5 percent weight boric acid. Neither of these reactor coolant pump (RCP) seal water injection limits could have been met if the rate of boric acid make-up approached the charging system to reactor coolant system (RCS) make-up flow rate.

2. Portions of the chemical and volume control system (CVCS) charging flow are not injected into the RCS and are subjected to cooling at the seal water return heat exchanger. Both RCP seal water leakoff and charging pump mini-flow are not injected to the RCS and are returned to the charging header suction line after being cooled at the seal water return heat exchanger. Allowing the emergency boration flow to meet or approach the charging make-up flow rates would cause the charging header concentrations to approach 12 percent weight boric acid concentrations. This concentrated acid could have then been cooled well below the solubility temperature in the seal water return heat exchanger.

Net Positive Suction Head (NPSH) Concern:

In addition to the boric acid concentration concerns, the potential loss of boric acid transfer pump NPSH while using the emergency boration flow path was identified. This loss of NPSH stems from the following two factors that were not fully analyzed.

1. Boric acid transfer (BAT) pump flow rates were assumed to be limited to the design flow rate of 75 gpm. This flow assumption was not a bounding flow for the emergency boration flow path.

2. Operating procedures did not preclude multiple flow paths that included the boric acid storage tank (BAST) recirculation line while in the emergency boration operating mode.

The NPSH calculation was based upon an assumption that the pump would run at the design flow rate of 75 gpm. The margins within the calculation did not account for actual flow rates in excess of the design flow rate of 75 gpm. Operators do not have the ability to throttle flow through the emergency boration line or to set flow rate at a desired rate. Emergency boration flow is simply a function of the pump's developed head to match system resistance.

A hydraulic model was developed for the emergency boration flow path that allowed the maximum flow capacity to be calculated and documented. By minimizing charging pump suction pressure, the maximum emergency boration flow was calculated to be 105.72 gpm. Total flow through the BAT pump was calculated at 111.27 gpm, which includes the emergency boration flow plus a minimum recirculation flow back to the BAST through the BAT pump minimum flow orifice. At these flow rates, the available NPSH was found to be nearly 19 feet less than of the pump's minimum required NPSH.

Flow rates higher than what was assumed for the NPSH analysis had the potential for negatively affecting the NPSH in two ways. First, the greater the flow rate the greater the suction head must be to meet the pumps minimum NPSH requirements. Second, as flow rates increase, the pump suction line losses increase between the tank and the pump.

For reportability purposes, CNP has established the conservative position that the concerns discussed above could have rendered the emergency boration system inoperable, and therefore, represent a reportable condition in accordance with the guidance set forth in 10 CFR 50.73.

Cause of Event

The apparent cause for the inadequate NPSH and high boron concentrations was a failure to validate assumptions of the conceptual designs. System design should have prevented excess flow rates which could have resulted in both a loss of pump NPSH and the return of highly concentrated borated water to the seal water return heat exchanger. A contributing factor of the condition was engineering's failure to recognize this problem during subsequent design verification activities.

Analysis of Event

It is expected that the emergency boration system would have completed its design function if called upon in an actual emergency. This conclusion is based primarily on past operating experience of the emergency boration flow path. Although the emergency boration system has not been used to address reactivity concerns, this emergency boration flow path has been used regularly at the end of cycle life to quickly borate the RCS beyond shutdown requirements up to refueling water boric acid concentrations. Boration of the RCS is used for the purpose of RCS activity cleanup. CNP's Shutdown procedures routinely initiate emergency boration in the intergrated plant shutdown procedure. Operating experience has shown the emergency boration system will perform its design function in spite of the problem identified with BAT pump NPSH and boron concentration concerns at the seal water return heat exchanger.

Use of the emergency boration flow path has not caused pump damage to the point of rendering the emergency boration system inoperable and the seal water return heat exchanger has not been clogged with boric acid crystals because of the following mitigating conditions.

BAT pump NPSH concerns mitigating effects:

1. The past operability determination was based upon worst case assumptions, which produced very conservative results. Assumptions include the following:

a. BAST temperature assumed at high temperature alarm set point of 180F versus the normal operating range of 155-170F . This adds about 3.5 feet of NPSH margin.

b. Emergency boration flow rates were calculated based upon minimum system back pressure and maximum boric acid developed head capacities.

c. The effects that cavitation might have in reducing flow though the BAT pumps was not accounted for. As the cavitation occurs, bubbles displace fluid flowing through the pump and reduce pump capacity. Since the loss of NPSH is induced by the line losses at higher flow rates, the presence of cavitation would act to limit or reduce the rate or amount of cavitation that occurred. The presence of cavitation causes the displacement of fluid being moved by the pump. The reduction in flow will, to some degree, reduce or limit the amount of cavitation experienced within the pump.

2. Simplicity and reliability of the BAT pumps end suction design reduces the pump vulnerability to immediate cavitation damage.

3. Boric acid transfer pump performance has historically shown increased degradation at a higher flow.

Boric Acid Solidification At The Seal Water Return Heat Exchanger Mitigating Effects:

1. High RCP seal injection temperature alarms have in the past caused operations to reduce emergency boration flow by opening the recirculation valve back to the BAST. A caution in step 4.8 of OHP 4021.001.004 recognizes that use of the emergency boration flow path may result in excessive temperatures to the RCP seals. This practice would have increased the potential for NPSH concerns, but would have maintained lower boric acid concentration in the charging header.

2. Cooling water temperature in Seal Water heat exchanger was conservatively assumed to be 60F for determining solubility concentrations. Cooling temperature to this heat exchanger is generally maintained slightly higher at 75-80F. The solubility temperature limit for 12 percent boric acid is approximately 135F.

3. Streaming effects would cause higher fluid velocities as the blockage increased. Higher fluid velocity maintains boric acid crystals in the fluid stream to carry them along. Once the fluid exited the heat exchanger, the flow would quickly be combined with fluid exiting the volume control tank (VCT) at an expected higher temperature and cause the boric acid to go back into solution.

Because of operating experience and the mitigating conditions shown above this condition would not have resulted in an actual reduction of the degree of protection of the public health or safety.

Corrective Actions

A Unit 2 plant modification was implemented to reduce the BAST boric acid concentration and to adjust the system flow to prevent the loss of NPSH.

CNP will modify the Unit 1 BAST boric acid concentrations and system flow conditions prior to restart.

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. In CNP's March 19, 1999, response to Nuclear Regulatory Commission (NRC) letter, "Enforcement Actions 98-150, 98-151, 98-152 and 98-186 Reply to Notice Of Violation October 13, 1998," which identified programmatic weaknesses in the plant design and licensing basis, and the training and qualification of plant personnel, CNP established an engineering leadership plan to develop a new design control process that encompassed design input and verification, calculations, design document control and vendor technical information. A training and qualification of personnel leadership plan was also established to reinforce a nuclear safety culture for site personnel. This training included human error reduction and conservative decision making during the performance of engineering activities.

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

Previous Similar Events

The following LERs are similar to this event:

LER 50-316/2000-009-00, Common-Cause Ventilation Failure Results In Inoperable Auxiliary Feedwater Pumps

LER 50-316/2000-003-00, Containment Internal Concrete Structures Do Not Meet Design Load Margins

LER 50-316/2000-002-00, Operation Outside Design Bases And Entry Into Technical Specification (TS) 3.0.3 Due To Non-Conservative TS

The above represent 3 examples of CNP's failure to adequately control its design basis. Additional examples of CNP's failure to control its design basis have been reported. This event and the additional similar events occurred prior to the implementation of corrective actions to correct and prevent recurrence of the breakdown in the CNP design process.