NRC FORM 366 (4-95)

U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104
EXPIRES 04/30/98

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.

LICENSEE EVENT REPORT (LER)

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

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
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TITLE (4)
Functional Deficiency in the Setting of the Emergency Core Cooling System Throttle Valve Positions

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
08	30	96	96	029	00	09	29	96	FACILITY NAME	DOCKET NUMBER

OPERATING MODE (9): 5
POWER LEVEL (10): 000

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)

☐ 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)	☐ 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. T. Laudenat, Nuclear Licensing Supervisor	(860)444-5248

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	MONTH	DAY	YEAR
☐ YES (If yes, complete EXPECTED SUBMISSION DATE).	☒ NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On August 30, 1996, with the plant in Mode 5 at 0-percent power, an engineering evaluation determined that a functional deficiency in the setting of the Emergency Core Cooling System (ECCS) throttle valve positions was a condition which alone could result in the loss of the Charging (CHS) and High Head Safety Injection (SIH) safety functions in the recirculation phase.

The positions of the throttle valves was established during original start-up testing to ensure adequate injection flows and prevent pump runout. This testing was conducted under injection conditions and therefore, the suction boost provided by the Containment Recirculation Spray System (RSS) pumps during recirculation was not considered in the setting of the throttle valves. Additionally, Westinghouse identified that the ECCS pump runout margin associated with the impellers used at the plant may be less than that assumed in the original system design. Coupled with the RSS pump boost, this could result in pump flow rates in excess of maximum limits during the recirculation phase, potentially leading to pump damage and inoperability. This condition was reported at 1128 on August 30, 1996, pursuant to 10CFR50.72(b)(2)(iii)(D) as a condition which alone could have prevented the CHS and SIH systems from performing their safety function to mitigate the consequences of an accident.

Plant modifications will be implemented to ensure that the ECCS pumps will provide adequate injection flows and not runout during recirculation with RSS pump boost. The plant will be maintained in Mode 5 or lower until such time as the modifications have been completed.

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

I. Description of Event

On August 30, 1996, with the plant in Mode 5 at 0-percent power, an engineering evaluation determined that a functional deficiency in the setting of the Emergency Core Cooling System (ECCS) throttle valve positions was a condition which alone could result in the loss of the Charging (CHS) and High Head Safety Injection (SIH) safety functions in the recirculation phase. The current ECCS throttle valve positions were established without considering the suction boost pressure of the Containment Recirculation Spray System (RSS) pumps which would be present during the recirculation phase. The throttle valve position , coupled with a reduction in ECCS pump runout margin available relative to original design conditions, would result in CHS and SIH pump flow rates in excess of maximum limits during the recirculation phase, potentially leading to pump damage and inoperability. This condition was reported at 1128 on August 30, 1996, pursuant to 10CFR50.72(b)(2)(iii)(D), as a condition which alone could have prevented the CHS and SIH safety systems from performing their safety functions to mitigate the consequences of an accident.

The licensing basis of the plant requires that the recirculation phase be sustainable for post accident long term cooling. The RSS suction boost coupled with a reduction in CHS and SIH pump runout margin could cause the CHS and SIH pumps to become inoperable early in the recirculation phase. In this condition, the ability of the plant to maintain sufficient flow during the recirculation phase would be significantly reduced such that the decay heat boil-off rate would rapidly exceed the heat removal rate and thus compromise core cooling.

II. Cause of Event

The cause of this event is a deficiency in the original design of the system coupled with inadequate start-up testing. The positions of the throttle valves were established during original start-up testing in accordance with Westinghouse specifications to ensure that the ECCS pumps would provide adequate injection flows and ECCS pumps would not runout. However, this testing was conducted under injection conditions and therefore, the boost from the RSS pumps which would exist during recirculation was not considered in the setting of these valve positions.

Whereas pump boost as a condition is not of itself necessarily harmful to the operation of the ECCS, it is the cumulative affect of the following conditions that results in a pump boost magnitude that makes it deleterious:

- RSS pumps are used for the ECCS recirculation phase in lieu of the lower head Residual Heat Removal (RHR) pumps.
- The as-built performance of each RSS pump is approximately 7 percent higher than the original design curve.
- The RSS heat exchangers have a flow limitation of 4600 gpm due to tube vibration concerns, even though the RSS pump maximum flow is 5100 gpm. To preclude RSS heat exchanger flows higher than 4600 gpm, direct RSS pump injection during cold leg recirculation and during hot leg recirculation was prohibited by plant procedures in 1986. While this action resolved the RSS heat exchanger flow limitation problem, it contibuted to the CHS and SIH suction boost problem.
- Sand-cast type impellers are installed in the CHS and SIH pumps. Sand-cast impellers are generally more susceptible to cavitation at flows close to the specified runout flows. Based on information from Westinghouse, if an attempt is made to operate at or beyond the specified runout flow, cavitation will occur regardless of the Net Positive Suction Head Availible (NPSHA) at the suction of the pump.

Therefore, the specified runout flows should be treated as maximum allowable flows for acceptable pump operation.

The ECCS, as currently configured, is vulnerable to pump runout conditions during the recirculation phase. The system is vulnerable to pump damage and ultimately system inoperability.

III. Analysis of Event

This is being reported as a condition which alone could result in the loss of the CHS and SIH safety functions in the ECCS recirculation phase, pursuant to 10CFR50.73(a)(2)(v)(D). Specifically, the setting of the ECCS branch line throttle valves during start-up testing was not properly coupled to the RSS pump boost which would be available during the recirculation phase. The RSS pump boost available is of sufficient magnitude to result in CHS and SIH pump flow rates in excess of maximum limits, potentially leading to pump damage and eventual inoperability.

The potential for the ECCS to fail to meet the long-term cooling requirements was being investigated in response to industry reports that the throttle valves were susceptible to clogging and erosion during the recirculation phase. Initially, it was postulated that debris from containment, smaller than the sump screen 3/32" opening but larger than the clearance provided in the subject throttle valves, could become lodged in the valve passages and sufficiently reduce flow to below the minimum allowed to prevent core uncovery. It was subsequently determined that while the high velocities and differential pressures in the vicinity of these throttle valves would serve to prevent blockage, the same high velocities and differential pressures would result in valve cavitation and subsequent valve seat erosion to the point where eventually the throttling capacity of the valves could decrease. This potential decrease in throttling capacity could result in ECCS pump runout and subsequent inoperability.

While investigating the ECCS branch line throttle valve clogging and erosion issues, it was determined that the position of these throttle valves were established during original start-up testing under injection conditions and therefore, did not consider RSS pump boost which would be available during recirculation. Due to the substantial magnitude of the RSS pump boost during recirculation, the current valve positions would not preclude the runout of either of the ECCS pumps at any time, independent of valve erosion, and the ECCS pumps would experience pump damage and eventual inoperability. This pump boost condition had previously been identified in Westinghouse Letter NEU-91-611 dated October 1, 1991.

The Westinghouse Letter also identified an issue regarding the amount of runout margin available for the ECCS pumps manufactured by Dresser/Pacific Pumps utilized within the plant. It was previously assumed that the runout margin for the SIH and CHS pumps was 15 gpm or more beyond the specified design maximum flow rate. The following guidelines were established in 1991 to assess the impact on the unit:

- If an attempt is made to operate at or beyond the critical flow capacity of the impeller, cavitation would occur regardless of the NPSHA at the suction of the pump.
- These flow rates should be treated as maximum allowable flows for acceptable pump operation. These flow rates are acceptable only if the NPSHA satisfies the identified pump requirements.
- For the SIH pumps, Dresser Pumps has determined that the asymptote is located beyond 675 gpm and cavitation probably occurs on the suction impeller. The original design runout flow was 670 gpm for SIH pump "A" and 650 gpm for SIH pump "B" as specified in Technical Specification 4.5.2.h.

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

- For the CHS pumps, Dresser Pumps has determined that the asymptote is located beyond 560 gpm. The original design runout flow was 560 gpm as specified in Technical Specification 4.5.2.h.

Therefore, the design objectives for an acceptable solution to ensure that the ECCS is capable of meeting its design safety function are as follows:

1. Meet or exceed the minimum injection flow requirements delineated in the technical specifications during the injection phase.
2. Ensure maximum pump flows are maintained below those specified in Technical Specification 4.5.2.h during recirculation with boost from the RSS pumps considered.
3. Ensure minimum throttle valve clearances are greater than 3/32".
4. Ensure maximum throttle valve velocities are below that at which significant valve erosion would occur.

The solution to both the clogging and valve erosion issues is to reduce the throttling burden on the valves such that the revised valve clearances would be larger than the sump screen mesh clearance and would have associated fluid velocities below which significant erosion will not occur. The required reduction in the throttling burden on the valves could be accomplished through the installation of flow orifices in series with each throttling valve, thus maintaining the same net ECCS hydraulic resistance and original flow balance.

In order to address the RSS pump boost issue, the ECCS hydraulic resistance must be increased; however, it can only be increased in such a manner that does not result in deliverable flows less than the required injection flows for core recovery delineated in the technical specifications. To this end, the additional resistance required for pump boost may only be partially addressed by increasing the hydraulic resistance in the branch lines beyond that required to relieve the valve throttling burden to the extent allowed by the current system flow margin in the injection phase. The balance of the resistance must be derived from supplemental resistance only in the recirculation flow path.

IV. Corrective Action

A plant modification is being prepared to resolve the pump boost, valve clogging, and valve errosion issues. The proposed modifications will:

- Install restrictive orifices in selected ECCS branch lines to relieve the throttling burden on the branch line throttling valves. This will permit the valves to be set in more open positions while still satisfying the minimum required deliverable flows during the injection phase.
- Install restrictive orifices in the suction supply headers to the CHS pumps from the RSS pumps to mitigate RSS pump boost.

The plant will be maintained in Mode 5 or lower until such time as all modifications have been completed and the issues resolved.

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TEXT CONTINUATION

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V. Additional Information

Similar Events

None

Manufacturer Data

EIIS System Code
Chemical and Volume Control System - CB
High Pressure Safety Injection System - BQ