Indian Point 3
Nuclear Power Plant
P.O. Box 215
Buchanan, New York 10511
914 736.8001

New York Power Authority

William A. Josiger
Resident Manager

July 13, 1988
IP3-88-046
JAS-88-094B

Docket No. 50-286
License No. DPR-64

William J. Russell
Regional Administrator
U. S. Nuclear Regulatory Commission
Region I
475 Allendale Road
King of Prussia, PA 19406

Subject: NRC Bulletin No. 88-04,
"Potential Safety - Related Pump Loss"

Dear Mr. Russell:

Attachment I and II to this letter provides the Authority's response to the subject bulletin. Attachment I provides the Authority's written response to action items 1, 2, 3 and 4. Attachment II provides a justification for continued operations pending the completion of the Authority's technical evaluation of the two miniflow design concerns identified by the subject bulletin.

Should you or your staff have any further questions in this matter, please contact Mr. M. F. Peckham of my staff.

Sincerely,

W. A. Josiger
W. A. Josiger
Resident Manager
Indian Point 3 Nuclear Power Plant

WAJ/JAS/dw

SUBSCRIBED AND SWORN TO
BEFORE ME THIS 13th DAY
OF July, 1988.

LORRIE A. HAFNER
Notary Public, State of New York
No. 4828710, Dutchess County
Term Expires May 2, 1990

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Lorrie A. Hafner

cc: Document Control Desk (original)
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Resident Inspector's Office
Indian Point 3
U.S. Nuclear Regulatory Commission
P.O. Box 337
Buchanan, NY 10511

Attachment 1
Response to NRC Bulletin No. 88-04
"Potential Safety-Related Pump Loss"

New York Power Authority
Indian Point 3 Nuclear Power Plant
Docket No. 50-286

ATTACHMENT I

BULLETIN NO. 88-04: POTENTIAL
SAFETY RELATED PUMP LOSS

The following safety related core cooling injection pumps and piping configurations were reviewed for the miniflow design concerns discussed in Bulletin 88-04: 1) Safety Injection (SI), 2) Residual Heat Removal (RHR) and 3) Recirculation.

ACTION ITEM 1

Promptly determine whether or not its facility has any safety-related system with a pump and piping system configuration that does not preclude pump-to-pump interaction during miniflow operation and could therefore result in dead-heading of one or more of the pumps.

RESPONSE

The three high-head Safety Injection pumps are not affected by the dead-heading phenomena because an orifice exists on each pump's individual miniflow line prior to connection to a common miniflow line. This orifice is designed to reduce pressure at the entrance to the common line so the weakest pump still has the ability to recirculate. This piping configuration desensitizes this system to the strong/weak pump miniflow concerns.

The two recirculation pumps are also not affected by this phenomena. These pumps have low flow protection provided by both a common miniflow line and an individual, 3/4 inch miniflow lines. The individual miniflow lines desensitize the system to the possibility of dead-heading a pump.

Although the recirculation pumps and the high-head SI pumps do have a piping configuration such that there is a common miniflow line, based on the above, it has been determined that potential for damage due to stronger pump dead-heading the weaker pump does not exist for these two pump and piping systems. Because of a shared common miniflow line, the pump to pump interaction potential described in Bulletin 88-04 exists only in the RHR system.

ACTION ITEM 2

If the situation described in Item 1 exists, evaluate the system for flow division taking into consideration (a) the actual line and component resistances for the as-built configuration of the identified system; (b) the head versus flow characteristics of the installed pumps, including actual test data for "strong" and "weak" pump flows; (c) the effect of test instrument error and reading error; (d) the worst case allowances for deviation of pump test parameters as allowed by the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section XI, Paragraph IWP-3100.

ATTACHMENT I

BULLETIN NO. 88-04: POTENTIAL
SAFETY RELATED PUMP LOSS

RESPONSE

Initial review of the RHR system has been done and the following determinations have been made:

1) There is no dead-head concern for the RHR pumps during normal operation. SOP-RHR-1 (Standard Operating Procedure) uses the pumps to cool down and remove decay heat with the RCS at low pressure. Reactor coolant is removed, cooled, then reinjected using these pumps, the miniflow lines are not required in this application.

2) For Indian Point No. 3's large break LOCA (Loss of Coolant Accident), there is no concern for dead-heading the RHR pumps during the injection phase, since the RHR pumps will be operating in the low-head safety injection mode and miniflow is not required. In the recirculation mode, any one of four pumps (two RHR pumps or two recirculation pumps) will satisfy the recirculation flow requirements, following a large break LOCA. In the recirculation mode, the operating pump is expected to be operating well above the minimum flow range.

3) The potential exists to dead-head the weaker RHR pump during a small break LOCA. As the operator progresses through Emergency Operating Procedure (EOP), E-0, "Reactor Trip or Safety Injection", both RHR pumps have received an auto start signal and if they have not started, the operator will manually start both pumps. E-0 will then direct the operator to check to ensure the RCS is intact and the operator at this point will then make the transition to EOP E-1, "Loss of Reactor or Secondary Coolant". E-1 will have the operator check to see if the RHR pump operation should be terminated. If RCS pressure is greater than 275 psig, the operator will stop the pumps.

However, following a small break LOCA, the RCS pressure typically remains above the shutoff head of the RHR pumps causing the RHR pumps to operate on a minimum flow. Because the RCS pressure does not fall below the shutoff head, no credit is taken for RHR injection to mitigate the small break LOCA.

4) For non-LOCA events, the RHR pumps will be initially operating at or near their shutoff head (i.e., on miniflow recirculation) and will be subjected to the potential dead-heading mode. For such events, the symptom-based EOP's utilize the RHR system to achieve cold shutdown. If both pumps start, pump-to-pump interaction could cause the weaker pump to dead-head with subsequent damage likely. The remaining pump will continue to operate on miniflow. Within approximately 30 minutes

the operating pump would be shutoff until it is needed for RHR cooling. It is considered highly unlikely that the stronger RHR pump, which had run successfully for some period of time at the beginning of the transient, would fail to operate when required during the controlled process of placing the plant onto RHR cooling several hours later during the recovery from the postulated events. At least one RHR pump is, therefore, expected to be available to provide RHR cooling during the long term recovery following non-LOCA transients.

The specific considerations in NRC Bulletin 88-04 will require a comprehensive review of the RHR system for flow diversion. The Authority has initiated such a system review. Each of the items identified in Item 2 of the bulletin will be addressed as part of this review. The Authority expects to complete this effort no later than February 1989. Following this review, any long term system or procedural modifications will be determined and applicable implementation plans established.

ACTION ITEM 3

Evaluate the adequacy of the minimum flow bypass lines for safety-related centrifugal pumps with respect to damage resulting from operation and testing in the minimum flow mode. This evaluation should include consideration of the effects of cumulative operating hours in the minimum flow mode over the lifetime of the plant and during the postulated accident scenario involving the largest time spent in this mode. The evaluation should be based on best current estimates of potential pump damage from operation of the specific pump models involved, derived from pertinent test data and field experience on pump damage. The evaluation should also include verification from the pump suppliers that current miniflow rates (or any proposed modifications to miniflow systems) are sufficient to ensure that there will be no pump damage from low flow operation. If the test data does not justify the existing capacity of the bypass lines (e.g., if the data do not come from flows comparable to the current capacity) or if the pump supplier does not verify the adequacy of the current miniflow capacity, the licensee should provide a plan to obtain additional test data and/or modify the miniflow capacity as needed.

RESPONSE

In parallel with the reviews discussed in item 2 above, the Authority has initiated an evaluation of the adequacy of the minimum flow bypass lines with respect to damage resulting from operation and testing in the low flow mode. This evaluation will address the following safety related centrifugal pumps: the SI pumps, RHR pumps and Recirculation pumps. The Authority expects to complete this effort no later than February 1989.

ATTACHMENT I

BULLETIN NO. 88-04: POTENTIAL
SAFETY RELATED PUMP LOSS

ACTION ITEM 4

Within 60 days of receipt of this bulletin, provide a written response that (a) summarizes the problems and the systems affected, (b) identifies the short-term and long-term modification to plant operating procedures or hardware that have been or are being implemented to ensure safe plant operations, (c) identifies an appropriate schedule for long-term resolution of this and/or other significant problems that are identified as a result of this bulletin, and (d) provides justification for continued operation particularly with regard to General Design Criterion 35 of Appendix A to Title 10 of the Code of Federal Regulations (10 CFR 50), "Emergency Core Cooling" and 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling System for Light Water Nuclear Power Reactors."

RESPONSE

This letter constitutes the sixty (60) day response required by the bulletin. As indicated in items 2 and 3, above, additional time will be required to complete the necessary evaluations. These evaluations are expected to be completed by February of 1989, at which time any long term corrective actions will be determined and applicable implementation plans established.

cc: Document Control Desk (original)
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Resident Inspector's Office
Indian Point 3
U.S. Nuclear Regulatory Commission
P.O. Box 337
Buchanan, NY 10511

Attachment 2

Justification For Continued Operation

"Adequacy of Pump Miniflow for the ECCS"

New York Power Authority

Indian Point 3 Nuclear Power Plant

Docket No. 50-286

JUSTIFICATION FOR CONTINUED OPERATION
ADEQUACY OF PUMP MINIFLOW FOR THE ECCS

BACKGROUND

One of the concerns noted in the NRC Bulletin 88-04, "Potential Safety-Related Pump Loss", was the adequacy of currently installed safety-related pump minimum flow capacity. Pump minimum flow requirements have been based on thermal rise considerations. Specifically, operation on miniflow should not result in reaching saturation conditions within the pump. The actual flow required to meet this criteria is typically between 5% and 10% of pump flow at the best efficiency point.

Pending a complete evaluation of safety related pump minimum flows, a Justification for Continued Operation (JCO) is provided based on the ability of the pumps to meet their required safety functions.

EVALUATION

The ability of a pump to operate at low flow rates for various time periods depends on many different pump characteristics; suction conditions, shaft design, bearing design, etc. To prevent damage, sufficient flow must be provided to prevent both short term and long term failures. Short term failures can be caused by thermal effects, long term failures can be caused by mechanical effects. Based on pump performance history and satisfactory surveillance results, long term wear mechanisms have not had a significant detrimental affect on the ECCS pumps to date. During the time period while a more complete evaluation is being performed, significant degradation from long term mechanisms is not expected. In addition, the ECCS pumps are not expected to operate at low flows or on miniflow alone, for long periods of time, while performing their safety functions. Therefore, for this evaluation and JCO only, short term failures will only be considered.

In order to prevent short-term, thermal related catastrophic pump failures, "thermal minimum flow" considerations should be addressed. "Thermal minimum flow" is the flow required to prevent the fluid inside the pump from reaching saturation conditions which could eventually lead to overheating, cavitation, vibration, and potential catastrophic pump failure.

As a centrifugal pump operates at reduced flows, the temperature rise of the fluid passing through the pump is increased due to the pump inefficiency. The pump hydraulic efficiency decreases as the pump flow is reduced. The calculation of the "thermal minimum flow" depends on pump horsepower, efficiency, developed head, and pump suction conditions (NPSH, temperature, pressure). The "thermal minimum flow" is based on pump temperature rise and system NPSH. The pump fluid temperature rise is given by the following equation:

$$Tr = H/(778 \times Cp \times Eff)$$

Where:

Tr = pump temperature rise

Cp = fluid specific heat

Eff = Pump efficiency

H = pump developed head

Solving the above equation for efficiency, and utilizing the pump performance curves, the minimum flow required to prevent saturation conditions in the pump suction can be determined. The pump nominal minimum flow should be greater than this calculated "minimum thermal flow" value to prevent cavitation and to assure no short-term failure due to thermal effects.

The following provides an evaluation of ECCS pumps relative to their ability to perform their safety related functions.

Safety Injection Pumps

Three safety injection (SI) pumps are provided which take suction from the RWST and inject into the Reactor Coolant System (RCS) via two injection headers. The SI pumps start automatically on a "SI" signal and provide emergency core cooling flow to mitigate Loss of Coolant Accidents (LOCAs) and also provide boron from the Boron Injection Tank (BIT) and the RWST to provide negative reactivity to mitigate Steam Line Break events (SLBs).

Following a LOCA, the RCS depressurizes as RCS inventory is lost. For the limiting small break LOCAs analyzed in FSAR Chapter 14, the RCS quickly depressurizes below the shutoff head of the SI pumps, allowing the SI pumps to inject into the RCS. For smaller break sizes, where the RCS may depressurize more slowly, no core uncovery is expected and thus, no fuel or clad heat up is predicted. For these smaller break sizes, however, the SI pumps may operate on the minimum flow loop for a period of time. The ability of the pumps to operate with adequate "thermal minimum flow" was, therefore, evaluated by Westinghouse.

The evaluation consisted of calculating the "minimum thermal flow" based on the pump suction conditions presented in Table 1. The calculation indicated that 15 gpm would be required to prevent adverse thermal effects. The SI pump minimum flow available is controlled by the individual orifices in the miniflow lines. These orifices provide a minimum of 25 gpm flow. Actual test data indicate that approximately 30 gpm of minimum flow is available. The actual available minimum flow exceeds the required "thermal minimum flow" and, therefore, no adverse thermal effects are expected. Pump minimum flow is, therefore, not expected to adversely affect the ability of the SI pumps to perform their safety function.

Residual Heat Removal Pumps

The Residual Heat Removal (RHR) pumps are used as part of the ECCS to inject water into the RCS following a large break LOCA during the ECCS injection phase of the transient. The RHR minimum flow is provided by a common line which takes flow from downstream of the pumps and residual heat exchangers and returns it to the pump suction. Because of this common piping arrangement, the RHR system is subject to the pump-to-pump interaction problem described in NRC Bulletin 88-04. This problem could cause the stronger of the two pumps to dead-head the weaker pump during low flow, parallel pump operating conditions when the pumps are operating only on minimum flow. The dead-heading could cause a total loss of minimum flow through the dead-headed pump. An evaluation on a similar pump at another Westinghouse plant indicated that the dead-headed pump could operate for approximately 10 minutes without failure. Continued operation in a dead-headed condition, however, could cause thermal related pump damage.

Following a large break LOCA, the RCS depressurizes and the RHR pumps inject water from the RWST into the RCS cold legs. As the RCS pressure is well below the shutoff head of the RHR pumps the pumps will inject into the RCS and do not need to operate on the minimum flow loop.

Following a small break LOCA, the RCS pressure typically remains above the shutoff head of the RHR pumps causing the RHR pumps to operate on minimum flow. Because the RCS pressure does not fall below the shutoff head, however, no credit is taken for RHR injection to mitigate the small break LOCAs.

Long term cooling, following LOCA events, is provided by ECCS recirculation. During this phase of ECCS cooling, the recirculation pumps take suction from the recirculation sump inside containment and return water to the RCS either directly or via the SI pumps. The RHR pumps provide a backup capability to provide this recirculation function, but are not required to meet post-LOCA long term cooling requirements.

In summary, the possibility for pump-to-pump interaction while the RHR pumps are operating on minimum flow, will not affect the ability of the ECCS to mitigate LOCA events. The ability to meet the requirements of GDC 35 and 10 CFR 50.46 are, therefore, not affected by the RHR pump-to-pump interaction issue.

The RHR pumps, however, do provide the ability to cool the reactor by releasing steam to the secondary plant following many postulated accident events. This ability is credited in the radiological consequences analyses performed for the non-LOCA and Steam Generator Tube Rupture events presented in FSAR Chapter 14. For these scenarios, if an "SI" signal is generated during the event, the RHR pumps will start and operate on miniflow. If both pumps start, pump-to-pump interaction could cause the weaker pump to dead-head with subsequent damage likely. The remaining pump will continue to operate on miniflow. Within approximately 30 minutes, the operating pump would be shutoff until it is needed for RHR cooling.

An evaluation was performed by Westinghouse to determine the ability of one pump to operate on minimum flow during the early part of these non-LOCA transients. The evaluations considered the suction conditions presented in Table 1. The required "thermal minimum flow" was calculated by Westinghouse to be approximately 50 gpm. The nominal available miniflow is approximately 450 gpm and, therefore, no short-term catastrophic failure due to adverse thermal effects are expected for this situation. It is considered highly unlikely that the stronger RHR pump, which had run successfully for some period of time at the beginning of the transient, would fail to operate when required during the controlled process of placing the plant onto RHR cooling several hours later during the recovery from the postulated events. Therefore, at least one RHR pump should be available to provide RHR cooling during the long term recovery following non-LOCA transients.

Recirculation Pumps

The recirculation pumps are provided to support post-LOCA long term cooling. During this phase of ECCS cooling, the RWST has been drained down to the low level setpoint and the cooling water supply is switched from the RWST to the recirculation sump using the "eight switch" sequence. By this time, the recirculation sump has filled with water from the RCS, ECCS accumulators and the RWST. The level has reached a point where the recirculation pumps can be started. Following the activation of switch four, the pumped flow from one recirculation pump passes through the RHR heat exchangers and then, is either injected into the RCS via the RHR cold leg injection lines, or supplied to the suction of the SI pumps, if the RCS pressure is above the recirculation pump shutoff head. The pump also supplies the Containment Spray System (CSS), as required.

Following a large break LOCA, the RCS quickly depressurizes below the shutoff head of the recirculation pumps. During recirculation, therefore, the recirculation pumps will inject coolant directly back into the RCS. Depending on the break size, some small break LOCAs are not expected to depressurize below the shutoff head of the recirculation pumps prior to reaching the switchover point from injection to recirculation. In this case, the recirculation pump will operate on minimum flow, until recirculation via the SI pumps is initiated. The decision to align for recirculation using the SI pumps is based on measured low head injection line flows. If the conditions to allow recirculation via the low head injection lines are not met, activating switch 5 will cause automatic alignment for high pressure recirculation. Once high pressure recirculation is established, the recirculation pump miniflow is no longer needed. The time period when the recirculation pumps would be required to operate on minimum flow only, during this switchover process, is anticipated to be no longer than 5 minutes.

An evaluation of the recirculation pump minimum flow capability was also performed by Westinghouse. The evaluation considered conservative suction conditions, as presented in Table 1. The calculated "thermal minimum flow" is 525 gpm. The nominal available minimum flow is assumed to be 125 gpm. Operation of these pumps, without damage, for extended periods of time (approximately 30 to 60 minutes) cannot be assumed because available minimum flow is less than "Thermal Minimum Flow". However, this is not expected to result in damage to the pump, based on the following:

1. The basis for the thermal rise minimum flow rate calculations is the prevention of the temperature rise in the pump creating saturation conditions in the pump suction. The method is conservative, in that it assumes recirculation of the discharge fluid directly back to the pump suction. During the time that the recirculation pump would be operating on minimum flow during switchover, the pump draws suction directly from the recirculation sump. The termal minimum flow calculations which require a minimum flow rate of 525 gpm were based on preventing a 2°F rise in the pump. Due to the large volume of water in the recirculation sump and the low minimum flow rate, the temperature in the sump is not expected to rise from the initial assumed 260°F to 262°F within the short time (approximately 5 minutes) that the pump might be operating on minimum flow.

2. The recirculation pumps are Ingersoll-Rand Model 24APK vertical pumps, which were especially designed for condensate and hot liquid service, and are more resistant to cavitation damage than most pump designs.

Summary and Conclusion

The above evaluations for the Indian Point Unit 3 ECCS pump minimum flow capabilities indicate that the Safety Injection, Residual Heat Removal, and Recirculation pumps will be able to perform their safety functions considering the available minimum flows, without causing any undue damage to the pumps. It is therefore concluded, that the above pumps are adequate to meet minimum flow capabilities, as designed, and are not subject to the concerns presented in IE Bulletin 88-04.

TABLE 1

INDIAN POINT UNIT 3

ECCS PUMP SUCTION CONDITIONS

Parameter	Units	HHSI Pumps	Recirc. Pumps	RHR Pumps
Design Flow Rate (per pump)	GPM	650	3000*	3000
Suction Temperature	°F	120	259**	120
Specific Gravity	--	0.99	0.94	0.99
NPSH Available	FT	42.1	10.6	59.4
Miniflow Capacity	GPM	30	125	450***
Flow Source	--	RWST	Recirc. Sump	RWST
LOCA Mode	--	Injection	Recirculation	Injection

* Datum is for a large break LOCA. For a small break LOCA, recirculation flow would be directed to the suction of two HHSI pumps and to both spray headers, as required. Total pumped flow will increase to 1000 gpm during this mode.

** Based on a saturation pressure of 35 psia (20 psig) which is the maximum Containment Pressure, due to operation of the Containment Spray System.

*** With one pump in operation.

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