

U.S. NUCLEAR REGULATORY COMMISSION  
REGION I

Report No. 50-309/90-23

Docket No. 50-309

License No. DPR-36

Licensee: Maine Yankee Atomic Power Company  
83 Edison Drive  
Augusta, Maine 04336

Facility: Maine Yankee Atomic Power Station

Inspection At: Wiscasset, Maine

Inspection Conducted: November 5-9, 1990

Inspector:

P. K. Eapen  
Dr. J. Yerokun, Reactor Engineer, Special Test  
Programs Section, EB, DRS

1/16/91  
date

Approved by:

P. K. Eapen  
Dr. P. K. Eapen, Chief, Special Test Programs  
Section, Engineering Branch, DRS

1/16/91  
date

Inspection Summary: Announced safety issues inspection of the licensee's implementation of NRC Bulletin 88-04.

Areas Inspected: Licensee's actions to address the concerns identified in Bulletin 88-04. Inspection guidance provided by NRC Temporary Instruction 2515/105.

Inspection Results: All safety-related systems with two or more pumps were evaluated for the problems discussed in Bulletin 88-04. No violations or deviations were identified. There were four (4) unresolved items (Adequacy of the high pressure safety injection system operation during fill and vent mode and alternate letdown mode - Section 2; Adequacy of a common six inch discharge line for all containment spray and low pressure safety injection pumps during minimum flow operation - Section 3; Discrepancy between actual and stated flow rate in the licensee letter for the containment spray system surveillance - Section 4 and Adequacy of 20 gpm flow rate for the emergency feed water system surveillance tests - Section 5) identified. It was noted that the licensee's reviews were relatively cursory and not very detailed. This resulted in changes to procedures and a commitment to revise the licensee's response to the bulletin by March 15, 1991.

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Attachment A, HPSI Minimum Flow Configuration

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## DETAILS

### 1.0 Scope Of The Inspection

The purpose of this inspection was to verify that the licensee had taken adequate measures to address the issues discussed in NRC Bulletin 88-04, Potential Safety Related Pump Loss.

#### Discussion

NRC Bulletin 88-04 primarily addressed two minimum flow (miniflow) design concerns. First is the potential for dead heading one or more centrifugal pumps in safety related systems when they have a common minimum flow line. The second concern is the adequacy of installed line capacity.

When two centrifugal pumps operate in parallel and one of the pumps is stronger than the other, (i.e. one pump has a higher developed head for the same flow) the weaker pump may be dead headed when the pumps operate in the minimum flow mode. The potential for dead heading exists at low flow rates because of the flatness of centrifugal pumps' characteristic curves in this range.

This inspection was conducted in accordance with NRC Inspection Manual (IM) chapter 2515, Temporary Instruction (TI) 2515/105.

Maine Yankee responded initially to the Bulletin by a letter, dated July 7, 1988. In this letter, Maine Yankee identified four Safety Related Systems that have minimum recirculation lines. These systems are :

- High Pressure Safety Injection (HPSI)
- Low Pressure Safety Injection (LPSI)
- Containment Spray (CS)
- Emergency Feedwater (EFW)

The licensee concluded that design, operation and surveillance practices preclude minimum flow problems as discussed in Bulletin 88-04. A follow up letter, dated January 2, 1990, to the NRC, provided further clarification on Maine Yankee's response to the bulletin.

The inspector reviewed drawings and systems description of all safety related systems with two or more pumps for the concerns discussed in the bulletin and verified that only the HPSI, LPSI, CS and EFW systems were relevant to the issues discussed.

## 2.0 High Pressure Safety Injection System

This system was inspected to ascertain the adequacy of the licensee's response to the bulletin. The inspection included :

- Review of Piping & Instrument Drawing (P&ID) No. 11550- FM-91B revision 23
- Review of licensee evaluations
- Review of ASME XI test results (Procedure 3.17.6.6 Revision 14)
- Review of licensee/vendor correspondence
- System walkdown
- Review of ECCS Operational Pump Flow and Check Valve testing (Procedure 3.1.15.3 revision 17) results

### Findings

Maine Yankee's HPSI system consists of three pumps each rated for 200 gpm at 5,500 ft total discharge head (TDH). The Best Efficiency Point (BEP) for the pump is 450 gpm at 4,500 ft (TDH). Each pump discharges into the Reactor Coolant System (RCS) through a 4-inch pipe. A one and a half (1.5) inch minimum flow recirculation line provides 50 gpm Minimum Recirculation (MR) for each pump. These lines, each with a pressure breakdown orifice and a check valve, merge into a common 2-inch pipe. The common 2-inch pipe discharges into the pumps' suction pipe at the Volume Control Tank through the seal water heat exchanger. A sketch of the configuration is shown on Attachment A.

The licensee found this configuration adequate and not susceptible to either the dead heading or inadequate flow issues. The licensee identified the following HPSI modes of operation at less than the rated flow:

- Loop Fill and Vent at 50 gpm MR plus 12-14 gpm of seal water on and off for 1.5 to 6 hours per year per pump.
- Alternate Letdown mode at 50 gpm MR plus 55 gpm letdown plus 2 gpm seal leakoff.
- Normal Letdown mode at 50 gpm MR plus 65 gpm charging plus 10 to 14 gpm seal water.

The pumps vendor's recommended minimum flows are :

- 80 gpm per pump for short term operation (2 hours or less in a 24-hour period)
- 128 gpm per pump for continuous operation (in excess of 2 hours in a 24-hour period)

The inspector identified two discrepancies in the licensee's documentation as follows :

- 1) Licensee's letter to the NRC, dated January 2, 1990, identified HPSI system's worst case operation as the fill and vent mode at 64 gpm for up to 6 hours a year. The above fill and vent operation appears not to be covered by the vendor's evaluation, as the licensee's letter, dated September 22, 1988, requesting the vendor evaluation stated that such operation would not exceed 1.5 hours per year.
- 2) In the Alternate Letdown mode (over 2 hours operation) the vendor's recommended minimum flow of 128 gpm was not being met. Plant procedure 1-11-6, Chemical and Volume Control System Operation, Revision 27, limits flow in this mode to 106 gpm.

The licensee contacted the vendor to obtain confirmation that the pumps are not subjected to accelerated degradation during the above modes of operation. The licensee agreed to resolve this issue in a letter by March 15, 1991. This item remains unresolved pending completion of licensee action to demonstrate that operating the HPSI system pumps during the fill and vent operation and the alternate letdown operation discussed above does not cause accelerated pump degradation. (Unresolved item no. 90-23-01).

The inspector performed a walkdown of the HPSI pumps minimum flow recirculation lines. No unsafe conditions were identified. A review of maintenance files indicated that the HPSI pumps were operated essentially trouble free.

### Conclusion

Maine Yankee's response provided design information, drawings and estimated operating times for minimum flow. The licensee concluded that the HPSI pumps were not vulnerable to the concerns of the NRC Bulletin based on the fact that these pumps historically experienced neither failures nor degradation since installation. However, there was no evidence showing that results of periodic pump tests were being compared with original baseline data to monitor pump degradation. Upon identification of this concern by the inspector, the licensee agreed to compare periodic pump test data to the baseline data and monitor for pump degradation during operation.

The inspector found that the HPSI pumps' minimum flow was adequate and that the system's configuration precludes the potential for pump dead heading.

### 3.0 Low Pressure Safety Injection System

The licensee determined that the LPSI system was not susceptible to the concerns addressed in the Bulletin. In their response to the Bulletin, the licensee stated that each of the LPSI pumps is provided with a separate recirculation (recirc.) line orifice which precludes the potential for dead heading. The current minimum flows were also considered adequate for pump protection.

#### Findings

Maine Yankee's LPSI system consists of two pumps each rated for 3,000 gpm at 365 ft total discharge head (TDH) with a shutoff pressure of 430 ft (TDH). The Best Efficiency Point (BEP) for each pump is shown as 4,000 gpm at 330 ft (TDH). The pumps discharge into the RCS through a ten inch pipe. Each pump is provided with a 3-inch minimum flow recirculation line from the discharge piping upstream of the discharge check valve. Each recirculation line has a pressure breakdown orifice and a check valve. The recirculation lines for these LPSI pumps merge with those for the Containment Spray pumps into a common 6-inch line and discharge to the Refueling Water Storage Tank (RWST). A sketch of the minimum flow configuration is shown in Attachment B.

The inspector discussed the adequacy of this six inch line when four pumps (two LPSI and two CS) operate in the minimum flow recirculation mode simultaneously. This item remains unresolved pending completion of licensee's action to demonstrate the ability of this six inch line to adequately handle simultaneous operation of the LPSI and CS pumps. (Unresolved Item No. 90-23-02).

The LPSI 3-inch minimum flow line was designed for a flow of 350 gpm originally recommended by the pumps supplier. Current In-Service Tests are performed at 400 gpm. The new recommended flows by the vendor are :

- Short term operation (2 hours or less) .....1100 gpm
- Continuous operation (over 2 hours) .....1500 gpm

The vendor also informed the licensee that at 350 gpm, the pumps are susceptible to considerable internal vibration and hydraulic instability and that the pump bushing could be damaged by the excess vibration action. Based on these concerns, the licensee disassembled and inspected one of the pumps (P-12A) in 1989. The pump was in good condition except for wear on the upper shaft bearings not attributable to hydraulic instabilities or low flow operation. The vendor independently reviewed the licensee's inspection findings and confirmed the licensee's determination. The

inspector reviewed the maintenance results and verified that they were as stated by the licensee. The other pump (P-12B) was also disassembled and inspected. Preliminary indications show no internal degradation due to hydraulic instabilities.

The licensee has determined that the current minimum flows for the LPSI pumps are adequate for pump protection based on the following :

- Internal inspection of the pumps indicated no pump damage
- Pumps have performed without problems for 17 years
- ASME Section XI test results indicate acceptable vibrations and temperatures during tests

However, the inspector noted that the licensee did not maintain records of engineering evaluations that demonstrated adequate minimum flow operation. Upon identification of this concern by the inspector, the licensee agreed to revise procedure 3.1.15.3, ECCS Operational Flow and Check Valve Testing, Revision 17, to include collection of pumps' suction pressure during testing for performance evaluation.

#### Conclusion

The plant addressed all issues of Bulletin 88-04. The current minimum flows provided for the pumps are less than the vendor's revised recommendations. However, the licensee has chosen to rely on good maintenance and operational history as the basis for determining system adequacy. The licensee has also contacted the vendor for further clarification on pump minimum flows and times in this mode. The inspector concluded that measures taken so far are adequate in ensuring that the LPSI pumps are protected from damage due to inadequate minimum flow.

#### 4.0 Containment Spray System

The licensee stated that the Containment Spray (CS) pumps are not susceptible to the concerns addressed in the Bulletin. Each pump is provided with a recirculation line with a pressure breakdown orifice to preclude the potential for dead heading during parallel operation.

#### Findings

Main Yankee's CS system consists of three pumps (two normally lined up with one as a backup) each rated for 3,700 gpm at 305 ft total discharge head (TDH) with a shutoff pressure of 420 ft (TDH). The Best Efficiency Point (BEP) for the pump is 4,750 gpm at 265 ft (TDH). Each pump is provided with a 3-inch minimum flow line. This line branches off the pump's discharge

pipe upstream of the discharge check valve. Each minimum flow line has a pressure breakdown orifice and a check valve. All three recirculation lines merge with those of the LPSI pumps into a common 6-inch line. This line discharges into the RWST. A sketch of the CS recirc. system is shown on Attachment B.

Each recirculation line was designed for a flow of 425 gpm as stated by the licensee. Current surveillance tests demonstrate the capability of each line at a flow of 300 gpm. Although this flowrate is above the minimum flow of 200 gpm now specified by the pump's vendor, the inspector noted that there was a difference between the test flowrate (300 gpm) and the flowrate (425 gpm) stated in the licensee's letter dated July 7, 1988 to the NRC. Upon identification by the inspector, the licensee agreed to review this issue for resolution. This item remains unresolved pending licensee's resolution of the discrepancy in flowrates. (**Unresolved Item no. 90-23-03**).

The inspector reviewed and found results of periodic tests, drawings, maintenance histories, and licensee/vendor correspondence to be acceptable. No other discrepancies were identified.

#### Conclusion

Maine Yankee's CS pumps are provided with adequate minimum flow. The recirculation lines are configured such that the potential for dead heading during parallel operation is precluded. The licensee's evaluations and correspondence with vendors were accomplished in accordance with the requirements of the Bulletin. The inspector concluded that adequate measures have been taken to ensure that the CS pumps are not susceptible to the concerns of Bulletin 88-04.

#### 5.0 Emergency Feedwater System

In the licensee's response to the Bulletin, the EFW pumps were considered not to be susceptible to the concerns of the Bulletin. The licensee's basis was primarily operational and maintenance histories and results of periodic tests.

#### Findings

The EFW system has two motor driven pumps each rated for 525 gpm at 1100 psig (2540 ft) with a shutoff pressure of 3200 ft total discharge head (TDH). The pump's Best Efficiency Point is 550 gpm at 2500 ft (TDH). Each pump is provided with a one inch minimum flow recirculation line. This line is from a six inch discharge pipe upstream of the discharge check valve. Each recirculation line has a pressure breakdown orifice and a check valve. The two



recirculation lines merge with that of the turbine driven auxiliary feedwater pump into a one and a half (1.5) inch pipe which discharges into the demineralized water storage tank. A sketch is shown on Attachment C.

The EFW minimum flow line is designed for a flow of 20 gpm. The licensee provided a list of estimated operating times for evaluation by the pump's vendor as follows:

- 4 hours per year at 20 gpm during normal operations
- 6 hours per year at 20 gpm during monthly tests
- 10 hours per year at 20 gpm MR plus 20 gpm system flow during post trip cooling
- 0.5 hours per year at 20 gpm during refueling surveillance tests (test performed at 525 gpm)

The vendor reviewed the above information and recommended the following minimum flows :

- 160 gpm for continuous operation (over 3 hours in a 24 hour period)
- 55 gpm for short periods (3 hours or less in a 24 hour period)
- 20 gpm for start/stop operation (15 minutes or less)

The inspector noted that the pump's minimum flow limitations were not strictly controlled within those specified by the vendor. The monthly surveillance procedure (at a flowrate of 20 gpm) does not limit the pumps' run time to 15 minutes. This item remains unresolved pending completion of licensee actions to demonstrate the adequacy of 20 gpm for EFW surveillance test.

**(Unresolved Item no. 90-23-04).**

The inspector reviewed results of past surveillance tests. At the flowrate of 20 gpm, an acceptable temperature rise of about 40° F was observed. Vibration levels were minimal and within limits specified in the procedure. The inspector performed a walkdown of the EFW pumps' minimum flow recirculation lines. No unsafe conditions were identified.

### Conclusion

Current test results and design requirements indicate that the EFW pumps have adequate minimum flow lines. However, the licensee needs to establish the adequacy of the monthly surveillance tests using 20 gpm.

#### 6.0 Overall Conclusion

The licensee adequately documented their response to the concerns addressed in the bulletin. All required systems were evaluated. The evaluations and documentation reviewed indicate that safety related systems at Maine Yankee are not susceptible to the concerns of Bulletin 88-04. However, the inspector observed that overall the review was incomplete. For example:

- A review of the operating procedure for the Chemical and Volume Control System indicated that continuous operation under certain conditions would result in flows less than that recommended by the vendor.
- The licensee had not considered the back pressure and velocity from parallel operation in the common six inch minimum flow line for the LPSI and CS pumps.
- A review of recent flow data (at or above rated flow) for the LPSI and CS pumps indicated that the pumps were operating at flows below vendor recommendations and preoperational testing. Additionally, the plant had not compared recent test results to preoperational and vendor test results.

Maine Yankee has had relatively failure free experience with their safety related pumps. Internal inspections of some pumps such as the HPSI and LPSI pumps have indicated the absence of degradation indicative of hydraulic instabilities. These facts provide adequate confidence that safety related pumps at Maine Yankee are not susceptible to the concerns addressed in Bulletin 88-04.

#### 7.0 Engineering Support

The inspector observed that licensee's management was kept abreast of engineering activities related to this bulletin. This was evidenced by the level of awareness shown by the Plant Engineering Manager. Also guidance has been provided to the operations personnel in the Control Room relating to the issues of this bulletin.

The thoroughness of technical resolutions as related to issues of Bulletin 88-04 was incomplete. Several observations (discussed in paragraph 6.0) indicated that the level of review was not very detailed. Some of these observations resulted in changes to procedures and a commitment to revise the licensee's response to the bulletin.

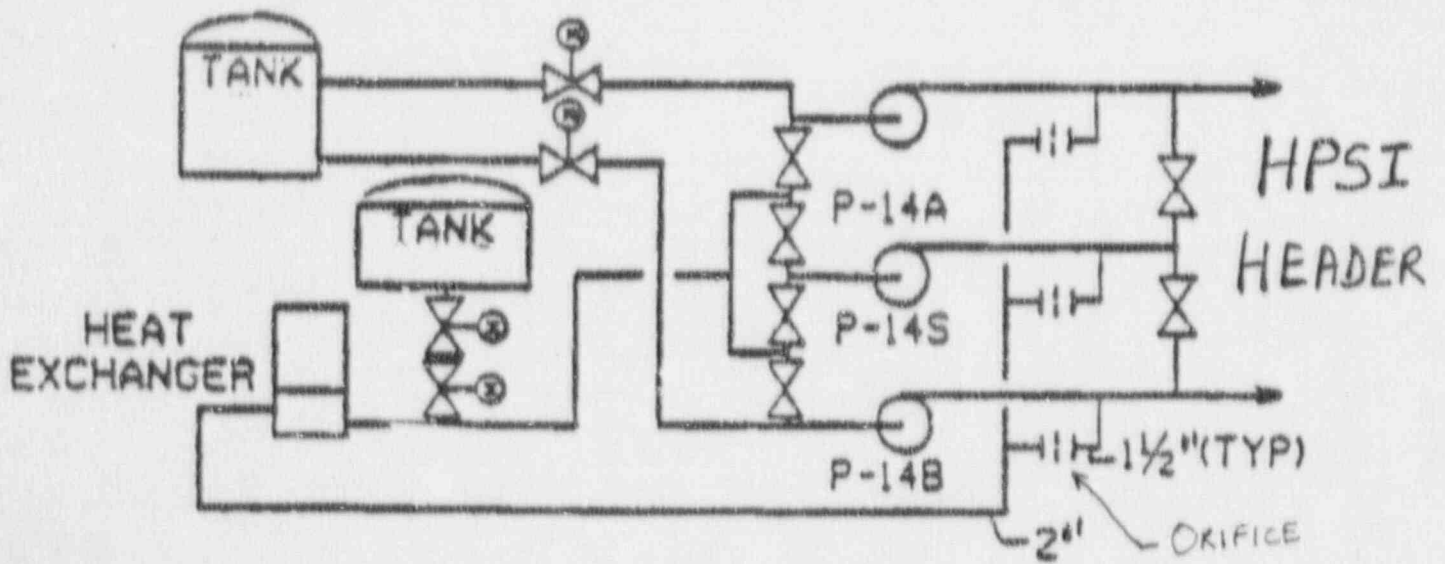
The engineers involved in this inspection were knowledgeable and they demonstrated good technical capabilities.

#### 8.0 Exit Meeting

The inspector met with those denoted in Attachment D on November 9, 1990 to discuss the preliminary inspection findings as detailed in this report. At no time during this inspection did the inspector provide written material to the licensee. The licensee did not indicate that the inspector was provided any proprietary information during this inspection.

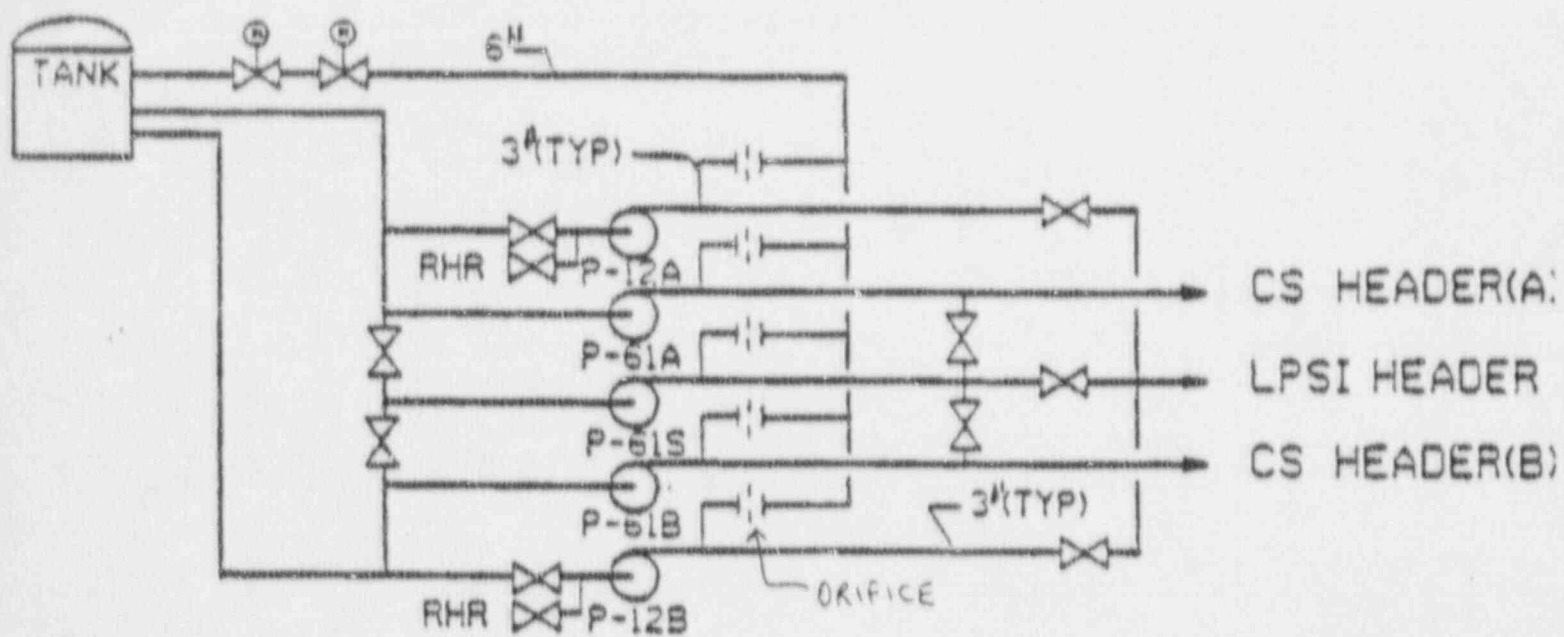
ATTACHMENT A

HPSI Minimum Flow Configuration



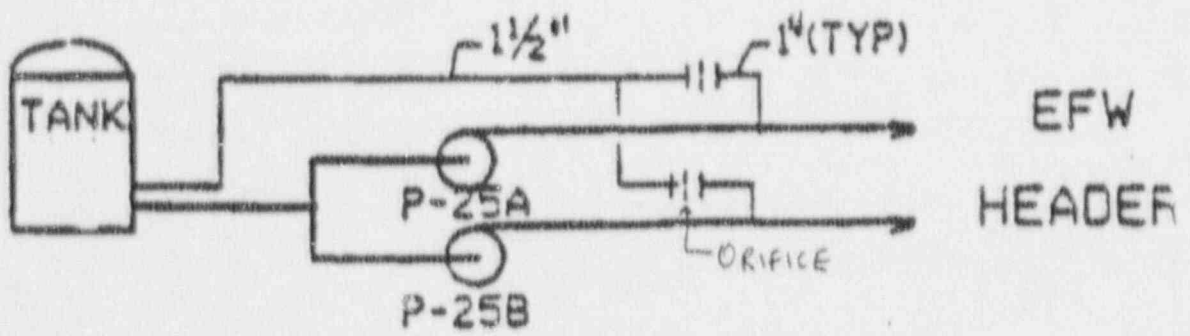
ATTACHMENT B

LPSI and CS Minimum Flow Configuration



ATTACHMENT C

EFW Minimum Flow Configuration



ATTACHMENT D

Persons Contacted

Maine Yankee Personnel

- \* Jim Hebert, Manager, Plant Engineering
- \* Russell Prouty, Assistant Plant Manager
- \* Christopher Shaw, Engineering Section Head
- \* Bill Schubert, Performance Engineer
- \* Lincoln Speed, Reliability Engineer

State Of Maine Personnel

- \* Pat Dostie, State Nuclear Safety Inspector

NRC

- \* Charles Marschall, Senior Resident Inspector
- Bill Oliveira, Reactor Inspector

- \* Denotes persons present at exit meeting