Boston Edison
Pilgrim Nuclear Power Station
Rocky Hill Road
Plymouth, Massachusetts 02360

L. J. Olivier
Vice President Nuclear Operations
and Station Director

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BECo Ltr. #96.013

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Docket No. 50-293
License No. DPR-35

Pilgrim's 180-Day Response to Generic Letter 95-07

References: 1.) Generic Letter 95-07, "Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves (BECo #1.95.131)

2.) Boston Edison 60-Day Response to Generic Letter 95-07, dated October 16, 1995 (BECo #2.95.108)

The NRC requested licensees evaluate the operational configurations of safety-related, power-operated gate valves for susceptibility to pressure locking and thermal binding and take any needed corrective actions to ensure susceptible valves are capable of performing the safety functions within the current licensing basis. This letter transmits our 180-day response to the generic letter.

We have reviewed 237 safety-related, power-operated valves at Pilgrim. Our bases for determining susceptibility to pressure locking and thermal binding are included in Attachment 1. We determined 15 valves, listed on Attachment 2, are susceptible to pressure locking or thermal binding.

Attachment 3 contains a summary description of the evaluations performed for the valves we determined to be susceptible to pressure locking or thermal binding. Also included is a brief description of the actions taken to eliminate the susceptibility of these valves. We have not included descriptions for the valves determined not to be susceptible; however, these evaluations

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Commitment:

A procedure change to eliminate possible pressure locking of the RHR pump torus suction valves is currently being processed. This is further described in Attachment 3, pages 5 and 6. We expect this to be completed by 3/31/96.

This completes our action for this generic letter. Should you have any questions, please contact Marie Lenhart, 508-830-7937, in our Regulatory Affairs Department.

L. J. Olivier

L. J. Olivier

Then personally appeared before me, L. J. Olivier, who being duly sworn, did state that he is Vice President Nuclear Operations and Station Director of Boston Edison Company and that he is duly authorized to execute and file the submittal contained herein in the name and on behalf of Boston Edison Company and that the statements in said submittal are true to the best of his knowledge and belief.

My commission expires: April 15, 1999 — DATE

Marie Lenhart — NOTARY PUBLIC

MARIE T. LENHART NOTARY PUBLIC

ETB\MTL\pkk\rap96\RESP9507

Attachments:
1. Bases for Susceptibility
2. Susceptible Valves
3. Evaluation of Susceptible Valves

cc: Mr. R. Eaton, Project Manager
Division of Reactor Projects - I/II
Mail Stop: 14D1
U. S. Nuclear Regulatory Commission
1 White Flint North
11555 Rockville Pike
Rockville, MD 20852

U.S. Nuclear Regulatory Commission
Region I
475 Allendale Road
King of Prussia, PA 19406

Senior Resident Inspector
Pilgrim Nuclear Power Station

Boston Edison Calculation M600, Revision 3, was developed to evaluate PNPS motor-operated valves (MOVs) for susceptibility to pressure locking (PL) and thermal binding (TB). This calculation was completed in response to industry concerns that some safety-related, gate-style MOVs, with active safety functions to open, may become inoperable due to PL or TB.

Each safety-related, gate-style MOV valve was initially screened for susceptibility based on safety function and by response to specific criteria regarding valve action during normal, emergency and surveillance conditions. The criteria represented the basic condition that must exist in order for either PL or TB to occur. A positive answer to any of these questions indicated potential susceptibility and required further evaluation of the valve.

This further review specifically addressed all operating modes of the valve (i.e., normal, emergency, test, shutdown and start-up) to determine the valve position required during the mode and the potential for TB and/or PL. Particular attention was paid to conditions prior to, during and following emergency operation. All credible normal and abnormal operating scenarios were considered. For valves that are normally open and have an active safety function to open, but are temporarily closed during a surveillance, a review of the surveillance procedure was completed to determine whether susceptibility to PL or TB should be considered.

In some cases, the specific scenario that could result in TB was compared to actual plant experience. If the calculation determined a valve met the criteria for susceptibility to TB during a specific <u>normal or experienced</u> event, research of plant history and a review of motor-operator capabilities was made to determine whether TB has occurred during these events. If no indication TB resulted during the specific event when susceptibility existed, it was concluded, based on field results, that the valve/operator design is capable of mitigating the affects of TB.

Calculation M600 addresses safety-related MOV gate valves. To address the potential for susceptibility of other power-operated valves, we completed the following:

- A list of 237 PNPS safety-related, power-operated valves was generated. This list did not include solenoid valves which function only to supply air to instruments and that are typically of the poppet or globe-style.

- Valves were excluded from susceptibility to PL if the process fluid was not water or steam. Pressure locking requires water or steam to enter the bonnet cavity and become pressurized. With the absence of water or steam, PL will not occur.

- Valves were excluded if the valve was not a gate style. G.L.95-07 requires only gate-style, safety-related power-operated valves be evaluated.

- Valves were excluded from susceptibility to both PL and TB if a previous evaluation (e.g., Calculation M600) determined the valve was not susceptible. This exclusion applied only to MOVs.

The following screening criteria was used to evaluate PL and TB. Answering 'yes' to any of these questions could indicate a potential for PL and/or TB to exist, and further evaluation would be necessary.

Pressure Locking Assessment

- *Is the valve required to open to achieve its safety function?*
  Generic Letter 95-07 states that evaluations must be completed to ensure all power-operated, safety-related gate valves are capable of performing their safety function to open under all modes of plant operation. Valves with no safety function to open and/or remain open at all times during all operating conditions were excluded. Valves normally open, but closed for testing or surveillance during operation, were evaluated.

- *Does heat-up/cooldown occur? (for steam service only)*
  For valves installed in steam service systems, susceptibility to intrusion of steam into the bonnet is possible. A closed valve subjected to steam, followed by a cooldown, can trap condensate in the valve bonnet. As the condensate cools and decreases in pressure, more steam/water may be drawn into the bonnet cavity. If the bonnet cavity becomes completely water filled, reheating the valve may then increase the pressure of the trapped water to a pressure greater than line pressure. If this occurs PL may result.

- *Does a large ΔP across disc occur while the valve is in a closed position?*
  One basic scenario leading to PL requires a large pressure drop ΔP across the disc. Initially with the valve closed, high pressure on one side of the valve can cause the disc to move slightly away from the seat allowing pressurized fluid or steam to enter the bonnet. With high pressure fluid trapped in the bonnet any up/downstream depressurization may cause PL due to the large ΔP between the bonnet and line pressure.

- *Does increasing temperature follow closure (ambient or system source)?*
  If water remains in the valve bonnet cavity following valve closure and is not removed, excessive pressure build-up can result due to thermal expansion if the water is heated. Heat-up may be caused by contact with a system high temperature source or from a source outside of the system such as the affects of increasing temperature from high energy line breaks (HELBs). Pressurization due to heat-up will be affected by the amount of trapped air in the bonnet cavity.

- *Will the valve be required to open following up/downstream depressurization?*
  One common PL failure scenario involves depressurizing the system either upstream or downstream of the valve while the bonnet is pressurized. Following a rapid depressurization, a large ΔP exists across the disc. If the valve is required to open following such an event and the bonnet is pressurized, operation could be prevented.

- *Is the valve exposed to high pressure during testing?*
  In some cases, a valve which is normally closed and isolated from a high pressure source may be exposed to high pressure during testing. Specifically, a closed valve separated from a high pressure source by a second closed valve can become pressurized when the second valve is stroke tested. Under this scenario, the valve bonnet may become pressurized with steam or water that can set up pressure locking as described above.

<u>Thermal Binding Assessment</u> :

- *Is the valve required to open to achieve its safety function?*
  (see PL discussion)

- *Is the valve closed while hot?*
  One of the basic required conditions leading to TB is valve closure while the system is hot. Following valve closure in a "hot" system, differing thermal expansion coefficients of the valve body, disc and stem, as well as differing starting temperatures, can lead to uneven cooling. Such uneven cooling may force the disc further into the seat resulting in binding.

- *Does the system cool significantly after closing?*
  If a large differential temperature (ΔT) occurs following closure, uneven cooling (as described above) may occur.

- *Is the system cold when opening is required?*
  The above cooling scenario of a valve closed in a "hot" system may lead to TB if the valve is required to open without being reheated. TB can be reversed if the valve is allowed to be heated to its initial closing temperature.

Results:

Following a review of all PNPS safety-related, power-operated valves, it was determined that only a select number of MOVs were susceptible to PL or TB. None of the non-MOV, power-operated valves evaluated were found to be susceptible. Attachments 2 and 3 discuss all valves found to be susceptible and include actions taken or to be taken for each susceptible valve.

SUMMARY OF COMPLETED AND SCHEDULED MODIFICATIONS

Valve ID	Service	Susceptibility Resolution	Completion Date	Completed
MO1001-29A	'A' RHR Inboard Low Pressure Coolant Injection Valve	Connected body drain to downstream test connection	RFO10 (Spring 1995)	YES
MO1001-29B	'B' RHR Inboard Low Pressure Coolant Injection Valve	Modified packing leakoff & connected to downstream drain	MCO10 (Fall 1994)	YES
MO1001-34A	'A' RHR Torus Cooling/Spray Block Valve	Installed bonnet cavity relief valve	RFO10 (Spring 1995)	YES
MO1001-34B	'B' RHR Torus Cooling/Spray Block Valve	Installed bonnet cavity relief valve	MCO10 (Fall 1994)	YES
MO1001-7A	RHR 'A' Pump Torus Suction Valve	Procedural change to vent/drain	March 1996	NO
MO1001-7B	RHR 'B' Pump Torus Suction Valve	Procedural change to vent/drain	March 1996	NO
MO1001-7C	RHR 'C' Pump Torus Suction Valve	Procedural change to vent/drain	March 1996	NO
MO1001-7D	RHR 'D' Pump Torus Suction Valve	Procedural change to vent/drain	March 1996	NO
MO1301-17	RCIC Turbine Steam Supply Isolation Valve (Outboard)	Motor Operator Upgrades *	RFO10 (Spring 1995)	YES

SUMMARY OF COMPLETED AND SCHEDULED MODIFICATIONS

Valve ID	Service	Susceptibility Resolution	Completion Date	Completed
MO1301-49	RCIC Inboard Injection Valve	Drilled hole in vessel side of disc	RFO10 (Spring 1995)	YES
MO1400-25A	'A' Core Spray Inboard Injection Valve	Drilled hole in vessel side of disc	RFO10 (Spring 1995)	YES
MO1400-25B	'B' Core Spray Inboard Injection Valve	Drilled hole in vessel side of disc	MCO10 (Fall 1994)	YES
MO2301-4	HPCI Turbine Steam Supply Isolation Valve (Inboard)	Motor Operator Upgrades *	RFO10 (Spring 1995)	YES
MO2301-5	HPCI Turbine Steam Supply Isolation Valve (Outboard)	Motor Operator Upgrades and Valve replacement *	RFO10 (Spring 1995)	YES
MO2301-8	HPCI Inboard Injection Valve	Drilled hole in vessel side of disc	RFO10 (Spring 1995)	YES

* completed to address GL89-10

- ***MO1001-29A/B RHR Inboard Low Pressure Coolant Injection Valves***

Summary of Operation

Valves MO1001-29A/B are the inboard suction isolation valves for the low pressure coolant injection (LPCI) system. Per Reference 9, the active safety functions of these valves are:

1) to automatically open on LPCI loop selection logic
2) to automatically close on LPCI loop selection logic (i.e., if the alternate loop is selected)
3) to automatically close for containment isolation

Susceptibility to Pressure Locking

HELB Response Evaluation

Valves MO1001-29A/B are located in the 'A' and 'B' RHR Valve Rooms, respectively. A review of Reference 10 indicates that various HELBs outside of containment will cause local temperatures around these valves to increase substantially. Specifically, these breaks include:

Line Break/Location	Valve Affected	Ambient Temperature Increase
HPCI Steam/HPCI Valve Station	MO1001-29A	205°F
RWCU/RWCU Hx Room	MO1001-29B	107°F
Main Steam/ Main Steam Tunnel	MO1001-29A/B	134°F/146°F

The potential for PL resulting from bonnet overpressurization would depend on final bonnet cavity water temperature prior to valve operation. (Note: Since PL susceptibility is established below, a thorough evaluation of the effects of the above HELBs was not conducted).

Bonnet Pressurization During Operation and Testing

Pressurization could result from disc flexing caused by the high pressure downstream fluid leaking back through check valves 1001-68A/B. As a low pressure injection system, the MO1001-29A/B valves will only open once vessel pressure decreases to 400 psig (concurrent with other permmissives). This may result in > 600 psid between the valve bonnet and downstream system pressure and >1000 psid on the upstream side (assuming RHR pumps are not running). Thrust calculations for this MOV were completed using a maximum $\Delta P_{opening}$ of 462.2 psid (Reference 9). Following a depressurization event as described above, the ability of valves MO1001-29A/B to open could be severely challenged. Valves MO1001-29A/B are, therefore, considered susceptible to PL.

Actions Taken

To eliminate susceptibility to PL, the following modifications have been completed:

MO1001-29A

During RFO10 (Spring 1995), the existing body drain of valve MO1001-29A was connected to a downstream test connection. This connection provides a continuous vent path from the MO1001-29A bonnet cavity to the adjacent high pressure piping allowing equalization of the bonnet cavity pressure with downstream piping pressure. This configuration eliminates susceptibility to PL.

MO1001-29B

During MCO10 (Fall 1994), the existing packing chamber leakoff of MO1001-29B was reconfigured. With the packing chamber modified and the packing leakoff piped to the downstream (high pressure) piping, continuous venting of the bonnet cavity is achieved. This configuration eliminates susceptibility to PL.

- ***MO1001-34A/B RHR Torus Cooling/Spray Block Valves***

Summary of Operation

Valves MO1001-34A/B connect the LPCI injection line to the suppression pool. Per Reference 9, these normally closed valves have the following safety functions:

1) ma...lly open to permit torus spray/cooling
2) manually close for containment isolation
3) automatically close on LPCI initiation or 2/3 core coverage

Susceptibility to Pressure Locking

HELB Response Evaluation

Valves MO1001-34A/B are located in the 'A' and 'B' RHR quadrants. Following a HPCI steam line break in the torus compartment, Reference 10 predicts local ambient temperatures will reach 231°F within 33 seconds with an average ambient temperature following this HELB of approximately 150°F (over the next 120 minutes). Operation of these valves may not occur for a significant amount of time following the HELB, and therefore, significant valve bonnet cavity heat-up could result. Heat transfer into the bonnet cavity would be enhanced due to steam condensing directly on the valve body metal. Based on this informatien, valves MO1001-34A/B are potentially susceptible to PL following a HPCI HELB.

Bonnet Pressurization During Operation and Testing

This valve is typically subjected to low temperature/pressure conditions. Operation of these valves during the Shutdown Cooling (SDC) mode of RHR could not occur due to line-up configuration, and therefore, any pressurization due to SDC would not affect valve mission.

Following heat addition to the suppression pool (i.e., due to RCIC, HPCI, or ADS operation), opening valve MO1001-34A/B is required for torus cooling. Valves MO1001-34A/B are separated from the torus air space by the closed MO1001-36A/B and MO1001-37A/B valves, and therefore, heat conduction through these lines is not expected.

The RHR pumps would be in operation prior to initiation of torus cooling/spray, and as a result, pressurization of MO1001-34A/B bonnet cavity to RHR pump discharge pressure may result. This pressurization will not affect the ability of these valves to operate, because operator sizing considers this maximum pressure. Additionally, scenarios causing a rapid depressurization of piping upstream of MO1001-34A/B concurrent with the required initiation of torus cooling/spray are not considered credible, and therefore, PL due to RHR pump operation is not anticipated.

Actions Taken

The packing chamber of valves MO1001-34A/B were modified to allow for continuous communication between the bonnet cavity and the packing leakoff connection. Following this modification, a pressure relief valve was installed on each leakoff connection and set to a relief pressure of 350 psig ($\approx$ 25 psig greater than RHR pump shutoff head). The pressure relief valve will allow for venting of the bonnet cavity if pressure increases result due to dramatic ambient temperature increases. This configuration eliminates susceptibility to PL.

- ***MO1001-7A/B/C/D*** ***RHR Pump A,B,C,D Torus Suction Valves***

Summary of Operation

These valves connect the RHR pump suction line to the suppression pool. Per Reference 9, the active safety function of these valves is to open to align for the operation of LPCI. These valves remain closed during RHR Shutdown Cooling (SDC) operation and remain open for all safety related functions.

Susceptibility to Pressure Locking

HELB Response Evaluation

The valves are located in the RHR quadrants and are normally closed at the start of and for the duration of RHR SDC operation. A loss of coolant accident (LOCA) during shutdown cooling (prior to reaching cold shutdown) would require re-alignment of RHR from SDC mode to LPCI mode. Realignment would require tripping the RHR pumps followed by the closure of valves MO1001-43A/C(B/D) and the opening of valves MO1001-7A/C(B/D). A review of References 10 and 13 was completed to determine whether the worst case temperature increases in the 'A' and 'B' RHR quadrants, due to a LOCA, could affect the ability of these valves to open, due to the heat-up of trapped bonnet cavity water. The LOCA event was modeled (Reference 13) assuming full power operation prior to the event and the loss of normal ventilation following the event. Under these conditions, an estimated 17°F rise in the 'A' RHR quadrant and a 12°F rise in the 'B' RHR quadrant will ultimately result. The peak temperatures occur in the 'A' and 'B' RHR quadrants approximately 7 hours ('A' RHR quadrant) and approximately 14 minutes ('B' RHR quadrant) after the start of the event. [These calculated quadrant temperature increases are conservatively high when considering actual vessel pressure/temperature during SDC initiation.]

It is assumed that re-alignment from SDC to LPCI would occur immediately in response to the LOCA event, and therefore, heat-up of trapped bonnet cavity water in valves MO1001-7A/C(B/D) would be negligible. PL resulting exclusively from this scenario is not anticipated.

Bonnet Pressurization During Operation

The MO1001-7A/B/C/D valves are normally open when the RHR system is aligned for LPCI operation; however, trapped bonnet cavity water may be present when the valves are closed for RHR SDC operation. These valves are located less than 2 pipe diameters from the RHR SDC piping. RHR SDC initiation may begin at pressures as high as 76 psig, corresponding to a temperature of approximately 308°F. However, per Reference 14, entry at or below 50 psig is recommended. Discussions with operations representatives and with the RHR system engineer indicate that entry typically takes place at approximately 20 psig (≈260°F) or less. Once initiating RHR SDC, cooldown to ≈ 80°F will take no longer than two days. Although temperatures are steadily decreasing, an initial ΔT of ≈180°F could exist between the bonnet cavity water and process fluid. With this ΔT, it is therefore reasonable to assume that significant valve bonnet heat-up due to conduction will occur.

Reference 14 provides steps for re-alignment from SDC to LPCI. Such a realignment may be required if, during shutdown, a pipe break were to occur. Under such a condition, attempts to realign the RHR system may be affected due to heat-up and thermal expansion of trapped bonnet cavity water. Pressure locking under this condition is possible.

Actions To Be Taken

PNPS Procedure 2.2.19 is being revised to require that the body drain valves of MO1001-7A/C or MO1001-7B/D remain open or that the bonnet cavity be drained immediately after alignment to SDC. Requiring this procedural step will eliminate the potential for bonnet cavity water pressurization due to heat-up during initial SDC operation. This configuration will eliminate susceptibility to PL.

An evaluation has been completed to address interim operability concerns.

- ***MO1301-17 RCIC Turbine Steam Supply Isolation Valve (Outboard)***

Summary of Operation

This valve allows steam from main steam line 'C' to enter the RCIC turbine. Per Reference 15, the safety function of this normally open valve is to close to meet 10CFR50 App. J leakage criteria in the event of a break of this line inside or outside of containment. This valve also has an active safety function to open upon RCIC initiation if closed for surveillance testing. This valve receives a close signal at reactor pressure less than 67 psig and, therefore, will be closed during shutdown and start-up.

Susceptibility to Thermal Binding

Thermal Binding Evaluation

Thermal binding of the MO1301-17 valve is possible if attempts are made to open it after it has been isolated while at full power. Under this scenario MO1301-17 would close and cooldown due to its distance from the 'C' Main Steam line (approximately 37 ft) per Reference 16. Per Reference 17, the MO1301-17 valve is required to be fully opened prior to operation of valve MO1301-16. As a result, no re-heating of MO1301-17 would occur before opening it, and therefore, thermal binding due to the large ΔT experienced following prolonged isolation is possible.

Actions Taken

During MCO10 (Fall 1994) and RFO10 (Spring 1995), modifications to MO1301-17 were completed to address GL89-10 concerns. The following changes were included:

- Replaced operator - SMB-000 to SMB-00
- Replaced Motor - 5 ft-lb to 10 ft-lb
- Changed Gearing - 33.5 to 72.0 overall ratio

These modifications have increased the opening thrust margin at reduced voltage, based on actual field test data, to 289% (93% assuming conservative design values for packing load and coefficient of friction). As a result of these changes, no additional actions are currently planned to address MO1301-17 valve susceptibility to TB.

A review of plant procedures found that valve MO1301-17 is closed at least twice per month to perform Tech Spec required surveillances. As discussed in Reference 25, MO1301-17 temperatures would be expected to drop from a normal operating value of ≈ 562°F to 90°F within 12 hours following closure. Closure for surveillance testing typically lasts for less than one shift (8 hours), and therefore, some amount of valve cooling is anticipated to occur. A review of historical records found no instances where failure to open following a surveillance test was reported. This review included operating history prior to the valve upgrade.

Prior to the GL89-10 operator upgrades, a maximum stall thrust of ≈ 26,000 lbs was calculated (Reference 29). During recovery from monthly surveillance testing, therefore, it can be concluded that opening thrust values never exceeded 26,000 lbs, based on historical record review. With no change to valve operation following the RFO10 modifications, opening thrust values will remain less than 26,000 lbs. Per Reference 30, the weak link of valve MO1301-17 in the opening direction is the stem tee head (30,787 lbs).

Lack of TB event occurrence may also be due to valve trim material interaction. The body and seat material of MO1301-17 are carbon steel, and the wedge and stem material are stainless steel, per Reference 31. Due to differing thermal expansion coefficients for carbon steel and stainless steel, during cooldown the stainless steel wedge and stem will contract more than the surrounding carbon steel. This reaction to cooling should avoid additional binding following closure.

Although this valve meets the Reference 1 criteria for susceptibility to TB, the ability to recover from these monthly surveillances indicates that the current valve and motor-operator are adequately designed to mitigate the affects of TB. Additionally, based on a review of Reference 30, fatigue affects due to higher than anticipated opening thrust values will not result in premature valve failure.

- ***MO1301-49 RCIC Inboard Injection Valve***

Summary of Operation

Valve MO1301-49 connects the RCIC pump discharge line to the RWCU line. Per Reference 15, the active safety function of this valve is to automatically open upon RCIC system initiation, and to automatically close on reactor pressure vessel isolation. The valve may be closed manually unless there is a RCIC signal present.

Susceptibility to Pressure Locking

HELB Response Evaluation

Valve MO1301-49 is located inside the TIP Room. A review of References 10 and 13 indicates that there are 5 unique HELBs which will result in local TIP Room peak ambient temperatures increasing by at least 40°F. Only one HELB is due to a RCIC steam line break in the TIP Room and in response RCIC would be unavailable. Further evaluation would be required to determine whether these HELBs could affect the ability of MO1301-49 to operate properly. Additional evaluation was not completed due to PL susceptibility discussed below. Reference 1 concludes that PL resulting from bonnet cavity overpressurization caused by an increase in cavity temperature increase is possible.

Bonnet Pressurization During Operation and Testing

Water can enter the valve bonnet during cold shutdown testing and quarterly pump testing; however, heat causing pressurization would not be expected to occur. There is approximately 70 ft (> 200 pipe diameters) of piping between the MO1301-49 and the downstream check valve 1301-50. Any leakage by the 1301-50 valve, that could reach the downstream side of MO1301-49, would not be able to maintain its starting temperature of ≈ 440°F per Reference 12.

Although leakage by the 1301-50 valve would not be expected to heat-up MO1301-49, pressurization of the valve bonnet could be possible. Pressurization could result from disc flexing caused by the high pressure downstream fluid leaking by the 1301-50 valve. Pressurization may affect operation if rapid depressurization of upstream or downstream piping results prior to valve operation. Vessel pressure will remain at or above 900 psig for any water pipe break (2" to 28" dia.), causing reactor low-low water level, which will initiate RCIC operation, Reference 18 Table 5-3. With vessel pressure at this level, no appreciable ΔP across the valve disc occurs, and therefore, the existence of PL would not be expected. For those pipe breaks which could cause pressure to drop below 900 psig, prior to reaching a low-low water level signal, (Core Spray and Main Steam Line break outside of containment), HPCI initiation will have already resulted due to high drywell pressure. A low-low water signal, initiating RCIC, will not have been reached (Reference 8, pages 5-7 through 5-9).

Manual operation of RCIC to assist in level control may be affected if initiation occurs following rapid vessel depressurization to pressures significantly less than 900 psig. Under this condition, a significant ΔP from the valve bonnet to the downstream side of MO1301-49 may exist prior to RCIC pump upstream pressurization.

Bonnet pressurization may also result during quarterly pump operability testing. During this test, RCIC is run in the test mode and pump discharge pressure reaches approximately 1110 psig (80 psig above vessel pressure), per Reference 19. During operation, RWCU pressure is assumed to have leaked back and pressurized the bonnet of the MO1301-49 valve to approximately 1050 psig. Therefore, the quarterly pump test may pressurize the bonnet to pump discharge pressure. This small differential would not be anticipated to affect the ability of the valve to open. However, if a pump test is completed prior to RWCU leak back and pressurization of the MO1301-49 bonnet, a different pressure configuration may result. Under this scenario following pump operation, the bonnet of MO1301-49 will be pressurized to approximately 1110 psig, with pressure upstream and downstream of the valve being negligible. The RCIC initiation signal will open valve MO1301-49 concurrent with the start of the RCIC pump, and therefore, sufficient upstream pressure may not be immediately available to eliminate/reduce the bonnet to upstream piping ΔP. The described scenario could affect the ability of MO1301-49 to properly operate in response to a RCIC initiation signal due to PL.

Actions Taken

The high pressure (vessel) side of the disc in MO1301-49 was drilled through during RFO10 (Spring 1995). The addition of this hole allows for continuous bonnet cavity to downstream piping pressure equalization. This configuration eliminates susceptibility to PL.

- ***MO1400-25A/25B Core Spray Inboard Injection Valves***

Summary of Operation

These inboard isolation valves connect the Core Spray pump discharge to the reactor vessel spargers. Per Reference 9 the valves are normally closed and open to allow initiation of the Core Spray system. These valves have the following safety functions:

1) open to initiate core spray on low-low water level (-49"), *and* low reactor pressure (<400 psig)
2) open to initiate core spray on high drywell pressure (2.5 psig) *and* low reactor pressure (<400 psig).
3) remote manually close to provide reactor and containment isolation.

Susceptibility to Pressure Locking

HELB Response Evaluation

These valves are located in the RWCU Heat Exchanger Room (MO1400-25A) and on the west side of the reactor building, 51' elevation (MO1400-25B).

MO1400-25A
Per Reference 10 there are two HELBs that significantly raise temperatures in the RWCU Heat Exchanger Room. One HELB is the failure of RWCU piping. Per Reference 20, App O, this failure is already assumed to disable MO1400-25A. This valve would also be affected by a HPCI steam line failure. Under this scenario, local temperatures could reach 250°F within 32 seconds and will slowly decrease to approximately 150°F over two hours. Assuming an initial ambient temperature of 80°F, it is apparent that while temperature falls from 250°F to 150°F, valve MO1400-25A will be heating up. Presuming a solid water filled bonnet cavity, heat-up could result in thermal expansion affecting the ability of the valve to operate properly. This valve may be required to open in response to a HPCI steam line failure. Further evaluation to determine what maximum room temperature will be reached prior to opening MO1400-25A was not completed due to susceptibility addressed below.

MO1400-25B
Per Reference 10 there are two HELBs that could significantly raise temperatures on the west side of the reactor building (51' elevation). The two HELBs, RWCU piping failure and HPCI steam line failure, could raise local temperatures to 212°F and 162°F, respectively. Although less severe than the effects on MO1400-25A, an increase in bonnet water temperature causing thermal expansion could result, potentially affecting the ability of this valve to properly operate.

Bonnet Pressurization During Operation and Testing

Pressurization could result from disc flexing caused by the high pressure downstream fluid leaking back through the check valves 1400-9A/B. As a low pressure injection system, the MO1400-25A/B valves will only open once vessel pressure decreases to 400 psig (concurrent with other permissives).

This will result in >600 psid between the valve bonnet and downstream system pressure and >1000 psid on the upstream side (assuming Core Spray pumps are not running). Thrust calculations for this MOV were completed using a maximum $\Delta P_{opening}$ of 447.8 psid (Reference 8). Following a depressurization event as described above, the ability of valves MO1400-25A/B to open would be severely challenged. Valves MO1400-25A/B are, therefore, considered susceptible to PL.

Actions Taken

The high pressure (vessel) side of the disc in valves MO1400-25A and MO1400-25B were drilled through during RFO10 (Spring 1995) and MCO10 (Fall 1994), respectively. The addition of this hole to each valve disc allows for continuous bonnet cavity to downstream piping pressure equalization. This configuration eliminates susceptibility to PL.

- ***MO2301-4 HPCI Turbine Steam Supply Inboard Isolation Valve***

Summary of Operation

Valve MO2301-4 allows steam from main steam line 'D' to enter the HPCI turbine, and per Reference 15 it has the following active safety functions:

a) close to meet 10CFR50 App. J leakage criteria in the event of a pipe break inside or outside of containment
b) open upon HPCI initiation if closed for surveillance testing of the valve

The valve will receive an automatic isolation signal while reactor vessel pressure is less than 100 psig. While open, the valves are exposed to reactor pressure and temperature.

Susceptibility to Thermal Binding

Thermal Binding Evaluation

Valve MO2301-4 may be susceptible to thermal binding if the valve has been isolated for an extended period of time during full power operation (such as during the performance of the surveillance procedures or following an LCO). Under this scenario, both the MO2301-4 and MO2301-5 will close isolating the valves from steam flow. Valve MO2301-4 is located approximately 30 feet away from the main steam line, per Reference 21. The HPCI steam line is insulated which could maintain Main Steam line temperatures up to the inlet of the valve. Following closure, the HPCI drain line located immediately upstream of MO2301-4 will remove any condensate that may form in the line that could act to draw more steam up to MO2301-4. Full cooldown of MO2301-4 is not anticipated. However, with actual system conditions following closure unknown, TB susceptibility may exist.

Actions Taken

During MCO10 (Fall 1994) and RFO10 (Spring 1995), modifications to MO2301-4 were completed to address GL89-10 concerns. The following changes were included:

- Replaced operator - SMB-2 to SB-3
- Installed compensating spring pack
- Replaced motor - 60 ft-lb to 100 ft-lb
- Changed Gearing - 41.51 to 76.26

Installation of a compensating spring pack will reduce inertial closing forces on MO2301-4 thus avoiding overseating the valve disc. In addition, these modifications have increased the opening thrust margin at reduced voltage, based on actual field test data, to 280% (108% assuming conservative design values for packing load and coefficient of friction). As a result of these changes, no additional actions are currently planned to address MO2301-4 valve susceptibility to TB.

Valve MO2301-4 is closed at least twice per month to perform PNPS surveillance procedures. Closures for surveillance testing typically last for less than one shift (8 hours), and therefore, some amount of valve cooling is anticipated to occur. A historical review of Problem Reports found one instance where valve MO2301-4 could not be fully opened when attempting to return HPCI to service (March 1981). Subsequent evaluations determined that the cause of this failure was due to improper torque switch setting coupled with thermal binding, although no basis for this conclusion was provided (per Reference 26). Prior to and since 1981, no reports of the inability of this valve to re-open when closed during operation have been made.

Lack of a TB event occurrence may be due to valve trim material interaction. The body and seat material of MO2301-4 are carbon steel, and the wedge and stem material are stainless steel, per Reference 31. Due to differing thermal expansion coefficients for carbon steel and stainless steel, during cooldown the stainless steel wedge and stem will contract more than the surrounding carbon steel. This reaction to cooling should avoid additional binding following closure.

Although this valve meets the Reference 1 criteria for susceptibility to TB, the ability to recover from these monthly surveillances indicates that the current valve and motor-operator are adequately designed to mitigate the affects of TB.

- ***MO2301-5 HPCI Turbine Steam Supply Outboard Isolation Valve***

Summary of Operation

Valve MO2301-5 allows steam from main steam line 'D' to enter the HPCI turbine and per Reference 15 has the following active safety functions:

a) close to meet 10CFR50 App. J leakage criteria in the event of a pipe break inside containment
b) open upon HPCI initiation if closed for surveillance testing of the valve

The valve will receive an automatic isolation signal while reactor vessel pressure is less than 100 psig. While open the valves are exposed to reactor pressure and temperature.

Susceptibility to Thermal Binding

Thermal Binding Evaluation

Thermal binding of the MO2301-5 valve is possible if opened after being isolated for an extended period of time while at full power. Under this scenario both the MO2301-4 and MO2301-5 close, at full power, and cooling of the MO2301-5 will result. MO2301-5 is located approximately 50 pipe diameters (Reference 21) from MO2301-4 that will isolate it from reactor vessel temperatures. When exiting surveillance procedures, the MO2301-5 valve is required to be fully opened prior to "jogging" open MO2301-4. As a result, no re-heating of MO2301-5 would occur prior to its operation. The potential for thermal binding is dependent on length of time closed, closing force, disc/seat/body temperature differential, and design configuration.

[If closed during an LCO, this thermal binding scenario would not affect the ability of valve MO2301-5 to perform its safety function. While the HPCI system is isolated for an LCO, MO2301-5 is unavailable and would not be required to [illegible] in response to an accident event.]

Actions Taken

During RFO10 (Spring 1995), modifications to MO2301-5 were completed to address GL89-10 concerns. The following changes were included:

- Replaced valve (new design)
- Replaced operator - SMB-1 to SB-2
- Installed compensating spring pack
- Replaced motor - 60 ft-lb to 80 ft-lb
- Changed gearing 27.2 to 52.57

Installation of a compensating spring pack will reduce inertial closing forces on MO2301-5 thus avoiding overseating the valve disc. These modifications have increased the opening thrust margin at reduced voltage, based on actual field test data, to 274% (94% assuming conservative design values for packing load and coefficient of friction). In addition, the new valve design, designed by Ring-O Valve and Kalsi

Engineering, incorporates the use of flexible elements in the disc and guide rails. This design enhancement was added to further reduce valve susceptibility to TB. As a result of these changes, no additional actions are currently planned to address MO2301-5 valve susceptibility to TB.

Valve MO2301-5 is closed at least twice per month to perform PNPS surveillance procedures. A cooldown from ≈ 562°F to 90°F in less than 24 hours is predicted (Reference 25). Closures for surveillance testing typically last for less than one shift (8 hours), and therefore, some amount of valve cooling is anticipated to occur. Since RFO10, no reports of the inability of this valve to open when closed during operation have been made. Therefore, although this valve meets the Reference 1 criteria for susceptibility to TB, the ability to recover from these monthly surveillances indicates that the current valve and motor-operator are adequately designed to mitigate the affects of TB.

- ***MO2301-8 HPCI Inboard Injection Valve***

Summary of Operation

The MO2301-8 valve connects the HPCI pump discharge to Feedwater line 'B'. Per Reference 15, this valve is normally closed and has an active safety function to open on HPCI initiation and to close for containment isolation. HPCI is initiated by coincidental signals of either low-low vessel water level or high drywell pressure (indicating pipe break inside containment).

Susceptibility to Pressure Locking

HELB Response Evaluation

Valve MO2301-8 is located inside of the TIP Room. A RCIC HELB could cause ambient temperatures in the TIP Room to reach 264°F (Reference 10) followed by a slow decrease after RCIC system isolation. During this time, MO2301-8 bonnet water pressure could increase due to valve heat-up. Heat-up would be enhanced due to the steam condensing directly on the uninsulated metal bonnet surface of MO2301-8, allowing for accelerated heat conduction. Cold water may have entered and remained in the MO2301-8 bonnet as a result of cold shutdown stroke testing, surveillance testing, and quarterly HPCI pump testing. Valve bonnet pressurization may increase with time since TIP Room temperatures remain high for an extended period following RCIC isolation. The faster the response of the HPCI system to a RCIC HELB, the less likely the valve will be exposed to an overpressurization condition. It is concluded that a RCIC HELB in conjunction with a delayed HPCI initiation response, may result in impeded operation of MO2301-8 due to bonnet pressurization.

Bonnet Pressurization During Operation and Testing

Water can enter the valve bonnet during cold shutdown testing; however, heat induced pressurization would not be expected. A review of the physical layout of this valve, found there is approximately 90 ft of piping between the MO2301-8 and the downstream check valve 2301-7. Any leakage by the 2301-7 valve, that could reach the downstream side of MO2301-8, would not be able to maintain its starting temperature (equal to feedwater temperature) due to heat transfer from the fluid to the piping and environment. Although leakage by the 2301-7 valve would not be expected to heat-up MO2301-8, pressurization of the valve bonnet could still be possible.

Pressurization could result from disc flexing caused by the high pressure downstream fluid leaking by the 2301-7 valve. Bonnet overpressurization may affect valve operation if depressurization of upstream and downstream piping results prior to the valve being required to operate. Under this condition, a large pressure drop between the bonnet and up/downstream sides of the valve, force the disc into the seat. For any water pipe break (2" to 28"), or steam line break outside of containment, vessel pressure will remain at or above 900 psig prior to reaching reactor low-low water (Reference 18, pages 5-7 through 5-10). For a core spray line or steam line break inside containment, an almost instantaneous HPCI initiation results due to high drywell pressure; therefore, reactor pressure would remain high. Under either pipe break scenario, HPCI initiation would result prior to any appreciable vessel depressurization, and therefore, PL would not be anticipated for these scenarios.

Bonnet pressurization may also result during quarterly pump operability testing. During this test, the HPCI pump is run in the test mode and pump discharge pressure reaches approximately 1225 psig (approximately 200 psig above vessel pressure, Reference 24). During normal operation it is assumed that feedwater leak back through check valve 2301-7 will have pressurized the bonnet of the MO2301-8 valve to approximately 1240 psig. Therefore, the quarterly pump test during operation can be assumed to not affect existing bonnet pressurization. However, if a pump test is completed prior to feedwater leak back and pressurization of the MO2301-8 bonnet, a different pressure configuration may result. Under this scenario following pump operation, the bonnet of MO2301-8 will be pressurized to approximately 1225 psig, with pressure upstream and downstream of the valve being negligible. This configuration may cause the valve to become pressure locked if immediately called upon to open.

Actions Taken

The high pressure (vessel) side of the disc in valve MO2301-8 was drilled through during RFO10 (Spring 1995). The addition of this hole to the valve disc allows for continuous bonnet cavity to downstream piping pressure equalization. This configuration eliminates susceptibility to PL.

References:

1. Calculation M600, Rev 3, "Motor-Operated Valve Pressure Locking and Thermal Binding Evaluation "
2. Drawing M-MOV1 Rev E31, "Motor Operated Valves - Information Table"
3. Drawing M-MOV2 Rev E16, "Motor Operated Valves - Information Table"
4. Drawing M-MOV3 Rev E27, "Motor Operated Valves - Information Table"
5. Drawing M-MOV4 Rev E15, "Motor Operated Valves - Information Table"
6. Drawing M-MOV5 Rev E21, "Motor Operated Valves - Information Table"
7. Drawing M-MOV6 Rev E14, "Motor Operated Valves - Information Table"
8. PNPS Q-List Rev E63
9. Calculation M563 Rev 6, "AC MOV Design Basis"
10. Specification E536 Rev 4 "Environmental Parameters for use in the Environmental Qualification of Electrical Components" [including referenced documents within E536]
11. PNPS Procedure 8.I.1.1 Rev 6, "Inservice Pump and Valve Testing Program"
12. Specification M300 Rev 39, "PNPS Specification for Piping"
13. Calculation N127 Rev 0, "Secondary Containment Heat-up Analysis After LOCA Without LOOP"
14. PNPS Procedure 2.2.19 Rev 57, "Residual Heat Removal"
15. Calculation M553 Rev 4, "Maximum Pressure Differential for DC MOVs"
16. Isometric Drawing M100BC21-3 Rev E3
17. PNPS Procedure 2.2.22 Rev 46, "Reactor Core Isolation Cooling System (RCIC)"
18. General Electric Report dated 11/91, "Safety Evaluation of the Water Level Spiking Phenomenon Observed at Pilgrim Nuclear Power Station"
19. PNPS Procedure 8.5.5.1 Rev 39, "RCIC Pump Operability Flow Rate and Valve Test at 1000 psig"
20. Pilgrim Nuclear Power Station Final Safety Analysis Report (FSAR)
21. Isometric Drawing M100BC27-3 Rev E1
22. PNPS Procedure 2.2.21 Rev 48, "High Pressure Coolant Injection System (HPCI)"
23. Isometric Drawing M100BC29-3 Rev E1
24. PNPS Procedure 8.5.4.1 Rev 46, "HPCI Pump and Valve Quarterly Operability"
25. S&SA94-32, "Cooldown Rate of RCIC/HPCI Steam Supply Line While Isolated"
26. PNPS Licensee Event Report (LER) #81-009/03X-1
27. NED93-256, "Design Basis Safety Functions of Selected MOVs for Generic Letter 89-10 (GL89-10)
28. Isometric Drawing M100BC22-3 Rev E2
29. Calculation M594 Rev 1, "MO1301-17 Closing Evaluation"
30. SUDDS/RF95-12, "MOV Weak Link Analysis (MO1301-17)"
31. Assembly Drawing M131A2-8 Rev E10
32. NESG 95-255, "Generic Letter 95-07, 90-Day Screening Evaluation for Pressure Locking and Thermal Binding