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SUBJECT: Forwards response to RAI needed to complete review of GL 95-07, "Pressure Locking & Thermal Binding of Safety Related Power-Operated Gate Valves."

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AUG 1 9 1996

United States Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

Serial: HNP-96-140

SHEARON HARRIS NUCLEAR POWER PLANT
DOCKET NO. 50-400/LICENSE NO. NPF-63
GENERIC LETTER 95-07, "PRESSURE LOCKING AND THERMAL BINDING OF SAFETY-RELATED POWER-OPERATED GATE VALVES"
ADDITIONAL INFORMATION

Sir or Madam:

On August 17, 1995, the Nuclear Regulatory Commission issued Generic Letter (GL) 95-07, "Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves." By letter dated February 13, 1996, Carolina Power & Light Company's (CP&L) Harris Nuclear Plant responded to the generic letter. On July 8, 1996, Harris Nuclear Plant (HNP) received a request for additional information in order for the staff to complete its review. On August 2, 1996, HNP responded requesting additional time until August 19, 1996 to review and validate our conclusions. The attachment to this letter provides the requested information.

Although the following valves are shown to meet operability requirements, the calculated thrust values do not have the margins CP&L believes are necessary in the long term. Therefore, CP&L will modify these valves to achieve greater margin by the end of Refueling Outage Seven or perform diagnostic testing to determine if more margin is actually available. The NRC will be notified in writing if testing confirms modification of the valves is not required.

1SI-86,	Normal High Head Safety Injection to RCS Hot Leg
1SI-107,	Alternate High Head Safety Injection to RCS Hot Leg
1SI-359,	Low Head Safety Injection to RCS Hot Leg
1SI-3 & 1SI-4,	Boron Injection Tank Outlet Valves
1RC-113, 115, & 117	Pressurizer Power Operated Relief Valve block valves

[illegible]

HNP would also like to clarify a response in the February 13, 1996 submittal. Specifically, body to bonnet "self-relieving" capability was considered in part, in the evaluations of the Containment Sump to Residual Heat Removal (RHR) Pump suction valves, 1SI-310, 1SI-311 and the Reactor Coolant System (RCS) loop isolation valves to RHR Pump suction, 1RH-1, 1RH-2, 1RH-39, and 1RH-40. Westinghouse design engineering and valve manufacturers have provided that bolted bonnet valves will "self-relieve" high bonnet pressures by elastic stretching of bonnet bolts and that the valves would not be damaged by this process. These valves are also equipped with a live-loading packing design which allows compression of the belville springs and movement of the packing and gland follower to limit bonnet pressure.

If you have any questions regarding this matter, please contact Mr. T. D. Walt at (919) 362-2711.

Sincerely,

W R Robinson

MV
Attachments

c: Mr. J. B. Brady (NRC Senior Resident Inspector - HNP)
Mr. S. D. Ebneter (NRC Regional Administrator, Region II)
Mr. N. B. Le (NRC Project Manager)

cc: Ms. P. B. Brannan
Mr. J. P. Cowan
Mr. G. W. Davis
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Mr. G. D. Hicks (BNP)
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Ms. W. C. Langston (PE&RAS File)
Mr. R. D. Martin
Mr. W. S. Orser
Mr. G. A. Rolfson
Mr. T. D. Walt
Nuclear Records
File: HI/A-2D
File: H-X-545

1. Regarding valves 1CT-102, 1CT-105, Containment Sump to Containment Spray Pump, and ISI-300, ISI-301, Containment Sump to RHR Pump, the licensee's submittal states that these valves were screened for thermally induced pressure locking, but that insulating water is maintained in the recirculation sump by operating procedures. The NRC staff believes that reliance on water filled containment sump piping to preclude thermally-induced pressure locking under design basis accident conditions is uncertain. Please provide information regarding your actions to demonstrate that water-filled piping will preclude thermally induced pressure locking of these valves for our review. Also, include heat transfer, thrust requirement and actuator capability calculations associated with these issues for our review.

<u>Response:</u>
The physical length of the insulating water column from the containment sump to the subject suction valves is approximately 29 feet, which includes a vertical drop of approximately 24 feet. Ambient temperature in the containment sump valve chamber is assumed to be 104 degrees F at the start of a design basis event. During a design basis event the containment sump temperature is calculated to rise to 240 degrees F. Heat transfer calculations were performed to develop a temperature profile for the containment sump piping during a design basis event. This profile shows that at approximately four feet below the sump the water temperature is essentially unaffected by the Loss Of Coolant Accident (LOCA) heat until the suction valves are opened.

This issue was previously addressed and evaluated as a result of NRC Information Notice 95-14 and reviewed by the HNP NRC Resident Inspector in NRC Inspection Report 50-400/95-05.

Since the water in contact with these valves will not be heated by the LOCA, the thrust requirements and actuator capability calculations performed for Generic Letter (GL) 89-10 are still valid and were included in Table "C" of CP&L's submittal to the NRC dated February 28, 1995 for GL 89-10 closure.

2. Valves 1SI-326, 1SI-327, RHR cross-tie, may be potentially susceptible to thermally-induced pressure locking caused by heat transfer from the RHR system during a design basis event. These valves appear not to have been addressed in the licensee's submittal. Please address this issue.

<u>Response:</u>

These valves are normally open and remain open during both cold leg and hot leg post LOCA recirculation. They are closed per an Emergency Operating Procedure (EOP) addressing a LOCA outside containment if splitting/isolating RHR trains is necessary to identify and isolate a break in the RHR system. The subsequent safety function for these valves to open is to provide hot leg recirculation to prevent boron precipitation.

Valve conditions at this time have not been fully evaluated, but are not expected to cause PL/TB. Valves 1SI-326 and 1SI-327 will be evaluated using PL/TB screen criteria by October 1, 1996. The NRC will be notified in writing if these valves are found to be susceptible to PL/TB.

3. Regarding valve 1SI-359, LHSI to RCS Hot Leg, the licensee's submittal states that RCS pressure could become trapped in the bonnet but this valve is not opened per emergency operating procedures until approximately 6.5 hours into a LOCA. The NRC staff believes that further information is required to provide assurance of the capability of this valve to perform its safety function. Please provide detailed information regarding the licensee's dispositioning of this valve with respect to the pressure locking concern.

<u>Response:</u>
During normal operations 1SI-359 is closed and isolated from the RCS by two check valves. Leakage of these check valves could allow RCS pressure to be present on the downstream gate valve disk. During a design basis LOCA, the RCS pressure would decrease to essentially zero psi, potentially trapping the 2235 psi RCS fluid in the bonnet. The design basis LOCA accident scenario assumes that power is restored to the actuator and that the valve is opened approximately 6.5 hours after LOCA initiation to allow low head safety injection recirculation flow to the RCS hot legs.

Commonwealth Edison (Com Ed) measured bonnet pressure decay rates for three valves subject to PL/TB. These valves were a 10" Borg-Warner, a 10" Crane and 4" Westinghouse flex-wedge gate valves. This information was transmitted from the Westinghouse Owners Group to member utilities in January 1996 (ESBU/WOG-96-022, dated 1/19/96). According to that report, the test data supports practical depressurization rates of 5.5 psi/min for bonnet pressures above 1500 psi, 4 psi/min for 1000-1500 psi and 2.5 psi/min for 500-1000 psi.

Using these depressurization rates, the bonnet pressure of 1SI-359 would decrease from 2235 psi to 1500 psi in approximately 2.5 hours and further decrease to 1000 psi after another 2 hours. After 6.5 hours the bonnet pressure would be approximately 700 psi.

A simplified conservative variation of the pressure locking equation used in the Com Ed methodology (Commonwealth Edison Company Pressure Locking Test Report, NUREG/CP-0152 page 3C-20) was used to approximate the thrust required to open this valve with a bonnet pressure of 700 psi as follows:

$$F(total) = F(static) + F(vert) - F(piston) + F(preslock)$$

Where:

F(total) is the total thrust required to unseat the valve.

F(static) is the static unwedging force as determined by actual field testing to be 22,500 lbs for 1SI-359.

F(vert) is the net force down on the disk due to the tapered seat angle on flex-wedge gate valves. For 1SI-359 F(vert) is 8,200 lbs.

F(piston) is the "stem ejection" force created by the bonnet pressure, 3,400 lbs for 1SI-359.

F(preslock) is the pressure locking force generated by the bonnet pressure and is given by:

$$F(preslock) = 2(A - a)(\text{Bonnet pressure})\ FV$$

Where 2 is the number of valve disks. When upstream and downstream pressures are not zero, the differential pressure across each disk must be considered and the equation becomes:

$$F(preslock) = (A-a)\ FV\ (\text{Bonnet pressure - upstream pressure + Bonnet pressure - downstream pressure})$$

For simplicity and conservatism, the hub of this Westinghouse flex-wedge gate valve is neglected for strength purposes. The area (a) of the hub however is subtracted from the effective disk area (A) subject to the locking pressure.

FV is a valve factor determined during the GL 89-10 Motor Operated Valve (MOV) program.

The value of F(preslock) for 1SI-359 is calculated to be 41,300 lbs. This value is conservatively higher than the Com Ed measured pressure locking forces for 10 inch valves with bonnet pressures of approximately 600 psi. The Com Ed values for Crane and Borg-Warner valves from NUREG/CP page 3C-23 are approximately 11,500 lbs and 18,800 lbs respectively at a bonnet pressure of approximately 600 psi.

Therefore substituting as follows:

$$F(total) = 22{,}500\text{ lbs} + 8200\text{ lbs} - 3400\text{ lbs} + 41{,}300\text{ lbs}$$

$$F(total) = 68{,}600\text{ lbs (unwedging thrust required)}$$

The actuator capability is evaluated by using the predicted minimum steady state voltage on the applicable Motor Control Center and calculating the motor terminal voltage and resulting motor and actuator torque using the methodology of the GL 89-10 MOV Program.

Actuator Torque = Motor Torque x Actuator Ratio x Pullout Efficiency

For the corresponding available thrust, the actuator torque is divided by the actual stem factor from the valve diagnostic test results.

The actuator capability determined for 1SI-359 is 69,600 lbs. Since the actuator capability of 69,600 lbs is greater than the required unwedging thrust of 68,600 lbs, the valve is expected to open when required.

Although this calculated margin is small, Com Ed test data for similar valves indicated larger margins. This Com Ed test data was taken for 10" flex-wedge gate valves with bonnet pressures in the 600 to 700 psi range. The 1SI-359 valve is also a 10" flex-wedge gate valve. To develop comparable opening thrust data, the tested values for pressure locking thrust are added to the static unwedging thrust, F(static) for 1SI-359. Therefore, the opening thrust requirements based on test data would be:

11,500 + 22,500 = 34,000 lbs and 18,800 + 22,500 = 41,300 lbs

When these valves are compared to the actuator capability of 69,600 lbs, the margin is considerably greater.

Since the calculated thrust margin available is small, CP&L will modify the valves to achieve greater margin by the end of RFO7 or perform diagnostic testing to determine if more margin is actually available. The NRC will be notified in writing if testing confirms modification of the valves is not required.

4. Regarding valves 1SI-86, Normal HHSI to RCS Hot Leg, and 1SI-107, Alternate HHSI to RCS Hot Leg, the licensee's submittal states that pressure locking is possible during the switch over to hot leg recirculation, but that restarting a CSIP will relieve it. The NRC staff believes that reliance on restarting a pump to relieve a potential pressure locking condition is uncertain. This is because the valve actuator may be damaged due to operation at locked rotor conditions between the time the valve is initially called upon to open, the pressure locked condition is correctly diagnosed by operations personnel, the pump is started and the pressure in the vicinity of the valve builds up sufficiently to relieve the pressure locked condition. Please address these issues.

Response:
Our original response was based on the motor thermal overloads providing damage protection. The PL/TB susceptibility of 1SI-86 and 1SI-107 was reevaluated using approach described in (3) above. This evaluation is summarized as follows:

These valves normally have RCS pressure downstream and Charging/Safety Injection Pump (CSIP) discharge pressure upstream. They are expected to be first opened during the recirculation phase of a LOCA to allow flow to the RCS hot legs approximately 6.5 hours after LOCA initiation. The valves are then closed and

reopened every 6.5 hours to shift recirculation between RCS hot and cold legs.

During normal operation the valve bonnet could contain approximately 2750 psi (CSIP discharge pressure). After a LOCA, using the Com Ed pressure decay rates, the bonnet pressure could be reduced to approximately 1000 psi in 6 hours. However, the actual bonnet depressurization will stop at 1450 psi which represents the CSIP discharge pressure during recirculation to a depressurized Reactor Coolant System (RCS). During the switchover to hot leg recirculation, the CSIPs are secured prior to opening 1SI-86 and 107. Therefore, these valves could be potentially pressure locked with 1450 psi in the bonnet and approximately zero psi upstream and downstream.

Using the Com Ed methodology described above the unwedging thrust required for 1SI-86 and 1SI-107 is 6,500 lbs. The evaluated actuator capability is 6,900 lbs. Therefore, these valves are expected to open.

Since the calculated thrust margins available are small, CP&L will modify the valves to achieve greater margin by the end of RFO7 or perform diagnostic testing to determine if more margin is actually available. The NRC will be notified in writing if testing confirms modification of the valves is not required.

5. Valves 1SI-1, 1SI-2, BIT Inlet Isolation, and 1SI-3, 1SI-4, BIT Outlet Isolation, may become pressurized from the reactor coolant system (RCS) or the charging system during normal plant operation and experience pressure locking during a design basis depressurization. A loss of offsite power could exacerbate these conditions. The licensee's submittal states that these valves are not susceptible to pressure locking. Please address these issues, and state why these valves are not susceptible to pressure locking.

<u>Response:</u>
Valves 1SI-1 and 1SI-2 are subject to CSIP discharge pressure during normal operation. During a LOCA the RCS could depressurize to a conservative zero psi. However, the operating CSIP would maintain pressurize on the upstream disk. This would place the valve in a differential pressure condition covered by the GL 89-10 MOV program.

If a LOCA with Loss of Off-site Power (LOOP) occurs before these valves unwedge, they could become momentarily pressure locked since the running CSIP would also lose power and depressurize the upstream side of the disk. The CSIPs and these valve actuators are re-energized by the Emergency Diesel Generator together in Load Block 1 by the Emergency Safeguards Sequencer. The restarted CSIPs would relieve the potential pressure locked condition.

The CSIPs reach essentially full pressure in less than three seconds. The temperature rise for locked rotor current applicable to 1SI-1 and 1SI- 2 at three seconds is 40 degrees C. The class B insulation of the motor is rated for a rise of 90 degrees C.

Therefore, the actuator motor should not be damaged by the short duration locked rotor condition and would open the valve normally when CSIP discharge pressure is established.

It is also appropriate to consider the valve and actuator's ability to withstand this short duration stall condition. An evaluation similar to those conducted for the 89-10 MOV Program determined the stall torque was less than the actuator limit.

In summary, if a LOOP occurs concurrent with the safety injection, the valves will still be expected to open after CSIP restart. Therefore, hydraulic pressure locking is not a concern.

The 1SI-3 and 1SI-4 (Boron Injection Tank (BIT) outlet valves) experience a similar situation. During normal plant operation, these valves are closed and isolated from the RCS by two check valves. Leakage past these check valves could allow RCS pressure to be present on the RCS side of the gate valve disc. During a LOCA, the RCS would conservatively go to zero psi, potentially trapping 2235 psig in the valves' bonnets. However, CSIP discharge pressure would place 1SI-3 and 1SI-4 in the differential pressure condition evaluated by the MOV Program.

If a LOCA with LOOP occurs before the valves could unwedge from the Safety Injection signal, the valves might not have immediate pressure assistance from the CSIPs when the Emergency Diesel Generators sequence Load Block 1 and energize the injection valves (1SI-1,2,3, and 4) and the CSIPs simultaneously.

The actuators for 1SI-3 and 1SI-4 are larger than the actuators for 1SI-1 and 1SI-2. The Com Ed methodology discussed above was used to determine the pressure locking thrust required and the actuator capability for this situation. The results showed the valves would open rather than stall the motor like 1SI-1 and 1SI-2. The unwedging thrust required is 18,100 lbs and actuator capability is 19,100 lbs. Therefore, the valves would open under LOCA with coincident LOOP conditions.

Since the calculated thrust margins for 1SI-3 and 1SI-4 available are small, CP&L will modify the valves to achieve greater margin by the end of RFO7 or perform diagnostic testing to determine if more margin is actually available. The NRC will be notified in writing if testing confirms modification of the valves is not required.

6. Based on a review of system diagrams, it appears that valve 1SI-52, HHSI to RCS Cold Leg, may become pressurized from the RCS during normal plant operation and experience depressurization induced (hydraulic) pressure locking during a design basis event. Please address this issue. In addition, the licensee's submittal states that the locking condition does not exist during the valve's opening safety function. Please provide additional information to clarify this wording.

Response:
This valve normally has RCS pressure downstream and CSIP discharge pressure

upstream. The bonnet of 1SI-52 would be pressurized by the operating CSIP during normal operating conditions since the pump discharge head (approximately 2750 psi) is slightly higher than RCS pressure. The valve is opened per the EOPs when lining up for the cold leg recirculation phase approximately 20 to 30 minutes after the LOCA initiation. It is conservative to assume that the RCS is depressurized and the two operating CSIPs are discharging through the BIT injection line. If only one CSIP is available, there would be no need to open 1SI-52 since train separation would not be needed. The CSIP discharge pressure would be approximately 2240 psi under these conditions. Therefore, the bonnet pressure could be about 510 psi greater than the upstream pressure and pressure locking could exist.

Using the Com Ed methodology gives a thrust required of 7,500 lbs and an actuator capability of 11,700 lbs. Therefore, the valve would be expected to open.

7. Regarding valves 1RC-113, 1RC-115 and 1RC-117, PORV block, licensee's submittal states that these valves are closed during normal operation to isolate a leaking PORV, but that they are required to open in response to a steam generator tube rupture accident. The NRC staff believes that this scenario may potentially result in pressure locking condition for these valves. Please address this issue.

   In addition, with regard to the potential susceptibility of these valves to thermal binding, the licensee's submittal states that existing plant procedures open the valve prior to cooldown. It is unclear if this situation also applies to a case where a PORV block valve would be shut to isolate a leaking PORV. It would appear that, if a PORV block valve is shut to isolate a leaking PORV, then the licensee would maintain the PORV block valve shut during plant cooldown. It would also appear that this scenario could lead to potential thermal binding condition if the valve is required to open for low temperature overpressure protection. Please address these issues.

   Response:
   For the Steam Generator (SG) tube rupture scenario, the RCS could depressurize to 1700 psi prior to opening the Power Operated Relief Valve (PORV) block valve. Therefore, upstream pressure of the block valve would be approximately 1700 psi, the bonnet pressure could be 2235 psi, and the downstream pressure would conservatively be zero psi. This condition could involve pressure locking, but the time between SG tube rupture and PORV opening is approximately 30 to 60 minutes. During this time, bonnet cooldown and natural disk leakage would be expected to relieve the trapped bonnet pressure. However, no credit was taken in the evaluation for a reduction in the bonnet pressure during this 30 to 60 minute period.

   An evaluation using the Com Ed methodology determined that the thrust required was 12,000 lbs and the actuator capability was 14,000 lbs. Therefore, these valves would be expected to open to mitigate the consequences of a SG tube rupture event.

   Since the calculated thrust margins for the PORV block valves are small, CP&L will modify the valves to achieve greater margin by the end of RFO7 or perform diagnostic

testing to determine if more margin is actually available. The NRC will be notified in writing if testing confirms modification of the valves is not required.

Regarding the operational practice of opening the PORV block valves during a plant cooldown, the procedure for plant cooldown from Mode 3 to Mode 5, requires the PORV block valves to be opened or verified open prior to cooldown. This requirement is to prevent potential thermal binding, and is applicable even if the associated PORV is leaking, as long as the PORV leak rate has no adverse affect on plant pressure control during shutdown. This procedural requirement has been in effect since August 1995 and PORV leakage has not adversely affected this practice. Therefore, since these valves are opened prior to cooldown, thermal binding would not impact the low temperature over pressure protection safety function of the PORVs.

8. Valves 1MS-70, and 1MS-72, Main Steam to AFW Turbine, may be potentially susceptible to thermally induced pressure locking if they exist in a configuration where steam condensate is permitted to enter the valve bonnet and a subsequent ambient heatup occurs, such as during a high energy line break. Please address this issue.

   Response:
   1MS-70 and 1MS-72 are located in the steam tunnel. Their upstream temperature and pressure conditions are approximately the same as the main steam lines. The main steam lines are the highest temperature piping in the steam tunnel; thus a steam line break which may increase the ambient temperature will not heat these valve bodies, since they are already at the highest possible temperature. Therefore, an ambient heatup event that could raise the temperature of these valve bonnets does not exist in the steam tunnel.

9. In Attachment 1 to Generic Letter 95-07, the NRC staff requested that licensees include consideration of the potential for gate valves to undergo pressure locking or thermal binding during surveillance testing. During workshops on GL 95-07 in each Region, the NRC staff stated that, if closing a safety related power-operated gate valve for test or surveillance defeats the capability of the safety system or train, the licensee should perform one of the following within the scope of GL 95-07:

   1. Verify that the valve is not susceptible to pressure locking or thermal binding while closed,
   2. Follow plant technical specifications for the train/system while the valve is closed,
   3. Demonstrate that the actuator has sufficient capacity to overcome these phenomena, or
   4. Make appropriate hardware and/or procedural modifications to prevent pressure locking and thermal binding.

   The staff stated that normally open, safety-related power operated gate valves which are closed for test or surveillance but must return to the open position should be evaluated within the scope of GL 95-07. Please discuss if valves which meet this criterion were

included in your review, and how potential pressure locking or thermal binding concerns were addressed.

Response:
HNP complies with the appropriate plant technical specification action statement for the train/system while the valve is closed. When testing is performed and applicable components are rendered inoperable, procedural steps invoke the required actions contained in HNP's Technical Specifications. Due to this approach, HNP did not include gate valves closed for surveillance testing in the scope of our PL/TB reviews.

10. Through review of operational experience feedback, the staff is aware of instances where licensees have completed design or procedural modifications to preclude pressure locking or thermal binding which may have had an adverse impact on plant safety due to incomplete or incorrect evaluation of the potential effects of these modifications. Please describe evaluations and training for plant personnel that have been conducted for each design or procedural modification completed to address potential pressure locking or thermal binding concerns.

Response:
HNP has not made equipment modifications at this time as a result of PL/TB and changes made to procedures were evaluated per 10CFR50.59 as not resulting in an unreviewed safety question. The following procedure changes have been made:

1. GP-002: (Plant heatup, Mode 5 to Mode 3) A check was added to insure the containment sumps contain the appropriate insulating water level.
2. OST-1118 & OST-1119: (Containment Spray Quarterly Operability Test) A step was included to stroke the pump discharge valves as appropriate after pump testing.
3. OP-111: (RHR System Operating Procedure) A step was included to stroke valves as appropriate prior to ECCS line-up completion.
4. EOP-EPP-11: (Transfer Between Cold Leg & Hot Leg Recirculation) An attachment was included to give a method to open a pressure locked valve if necessary.
5. EST-201 & MMP-012: (Hydro Test Procedures) A caution was added when gate valves are hydro boundaries.

No special training was conducted for these procedure changes.