QUAD CITIES STATION

ATTACHMENT 4

PRESSURE LOCKING AND THERMAL BINDING REVIEW GUIDELINE

PRESSURE LOCKING AND THERMAL BINDING SUSCEPTIBILITY

TABLE OF CONTENTS

PRESSURE LOCKING AND THERMAL BINDING SUSCEPTIBILITY

1.0 PURPOSE

This procedure establishes the criteria for determining which GL 89-10 motor operated gate valves (MOVs) are susceptible to pressure locking and thermal binding (PLTB). It also provides method to prevent or correct these phenomena.

1.1 Objectives

1.1.1 Establish the methodology for determining which MOVs are susceptible to PLTB.

1.1.2 Establish the criteria for justifying the basis for non susceptibility to PLTB and documenting the results.

1.1.3 Provide preventative and corrective measures for PLTB.

1.2 Applicability

1.2.1 All Safety-Related power operated valves

2.0 DEFINITIONS

Thermal Binding Phenomenon

If a wedge gate valve is closed while the system is hot, thermal binding can occur as the system cools. The valve body and discs mechanically interfere because of the different thermal expansion and contraction characteristics of the valve body, stem, and the disc. The difference in thermal contraction increase the unseating or pullout thrust. High closing forces can increase the thermal binding effect. In general, neither ac nor dc valve motor operator sizing analyses account for the extra force needed to unseat a valve when it is thermally bound. Solid wedge disc valves are effected more than flex or double disc valves. Parallel sliding valve unwedging forces are relaxed during opening due to the design and are therefore not effected by valve temperature changes (e.g. not susceptible to thermal binding).

Pressure Locking Phenomenon

Pressure locking in flex-wedge, double-disc, and parallel sliding gate valves is defined as the trapping of water at a higher pressure than the line pressure on either side of a closed disk. This phenomena is typically the result of rapid depressurization of the line pressure on one disk side (LOCA or loss of feedwater) followed by an initiation signal to open the valve.

A second way to cause pressure locking is to heat a closed valve with fluid in the bonnet. Increasing fluid temperature could cause an increase in bonnet cavity pressure due to thermal expansion of the fluid. The temperature increase can occur as fluid on either side of a disc heats up during various modes of plant operation or possible changes in ambient air temperature caused by a temperature transient in the valve area. Air and steam systems are not susceptible to thermal bonnet pressurization.

Solid-wedge gates are not considered susceptible to pressure locking due to their inability to seal on both seats.

PRESSURE LOCKING AND THERMAL BINDING SUSCEPTIBILITY

Active And Inactive Components

Inactive safety valves are those whose operability is not relied upon to perform a safety function during the transients or events considered in the respective operating condition category. However, these valves are required to remain in their normal position.

Active safety valves are those whose operability is relied upon to perform a safety function (as well as to accomplish and maintain a safe reactor shutdown) during the transients or events considered in the respective operating condition category.

3.0 PERSONNEL REQUIREMENTS

The evaluation of pressure locking and thermal binding should be performed by a team of personnel who collectively possess the following capabilities:

1. Knowledge of systems including familiarity with system design basis and operating requirements. This includes specific knowledge of valve operating requirements as described in the FSAR, Technical Specifications, Abnormal and Emergency Procedures, and Surveillance Procedures.

2. Knowledge of valve designs and operator sizing.

3. Knowledge of system operating pressures and temperatures, as well as, area temperature transients during accident conditions.

4. Knowledge of heat transfer mechanics.

4.0 DOCUMENTATION REQUIREMENTS

All results of the PLTB susceptibility review shall be documented in an approved Engineering Analysis. Forms contained in this procedure can be used to assist in documentation for valves in the MOV Program.

5.0 INSTRUCTIONS

The methodology used is depicted in attached flow charts (MOV Program PLTB Evaluation Methodology; MOV Program Pressure Locking Evaluation; MOV Program Thermal Binding Evaluation). Appendix A will be used to document the results of this evaluation

5.1 Determination of Gate Valve Population

PRESSURE LOCKING AND THERMAL BINDING SUSCEPTIBILITY

The scope of valves to be considered for PLTB under this procedure includes all power operated safety related gate valves with design basis open safety functions.

5.2 Determination of PLTB Susceptible Valves

5.2.1 Valve Type

5.2.1.1 Determine the valve type.

5.2.1.2 Exclude all valves which are not gate valves. Is valve a gate design? All valve designs with the exception of gate valves are excluded (i.e.; globe, butterfly) from PLTB phenomenon. Include a list of all excluded valves based on valve type.

5.2.2 Valve Functional Review

Use the form in Appendix A to document the following:

5.2.2.1 G1-Determine and document all required active and inactive design basis safety functions for gate valves.

5.2.2.2 G2-Determine and document if the valve is required to open per an EOP.

5.2.2.3 Exclude all valves which do not have an active or inactive open safety function. Include a list of all excluded valves based on function including basis for exclusion in the PLTB Engineering Analysis.

5.2.2.4 G3-Determine if the valve is repositioned for a surveillance procedure which results in moving the valve to its off normal position for an extended period (hours). This does not include ISI/IST stroke time testing or other surveillance's which cycle the valve open/close or close /open. These stroke time tests will not put the valve through a thermal transient. Pressure locking during the surveillance is not considered concurrent with a design basis event.

5.3 Determination of Gate Valve Population Susceptible to Pressure Locking (PL) or Thermal Binding (TB) Based Upon Disc Configuration

Use the form in Appendix A to document the following:

5.3.1 T1/P1-Determine and document gate valve configuration type. Typical valve disc designs include solid, flex, double, and parallel sliding:

(1) solid wedge designs are not considered susceptible to pressure locking. The solid disc design will either seat on both sides or not. If seated on both sides, this design will not allow leakage in or out of the bonnet. If the disc does not seat on both sides, pressure will not be trapped in the bonnet.

(2) parallel seat designs include a feature which releases the unwedging force during opening. This design is not susceptible to thermal binding.

PRESSURE LOCKING AND THERMAL BINDING SUSCEPTIBILITY

(3) flex and double disc designs are susceptible to both pressure locking and thermal binding.

5.4 Gate Valve Thermal Binding Susceptibility Evaluation (T)

Section T of the form in Appendix A shall be used to document the review of thermal binding susceptibility

5.4.1 If Parallel sliding disc design, skip Thermal binding evaluation (T)

5.4.2 Evaluation of a gate valve's potential susceptibility to TB shall be based upon the following assumptions.

(1) Normal room ambient temperature changes due to environmental changes will not be considered. Only environmental changes due to the accident (e.g. loss of HVAC or line break) will be considered when evaluating ambient air effects.
(2) Valve body, bonnet, and internals at temperature equilibrium prior to heat up or cool down.
(3) Valve body, bonnet, or disc/wedge orientation does not affect TB.
(4) Industry data and experience (e.g., NUREG-1275 and GL 89-10 Supplement 6) indicates that the following systems (BWR and PWR) have been involved in TB incidents. Careful comparison of similar-like unit-specific systems is required:
- HPCI steam admission valves;
- RHR suppression pool suction valves;
- containment isolation valves (sample line, letdown heat exchanger inlet header);
- HPCI injection valves

5.4.3 Evaluation of a gate valve's susceptibility to thermal binding (TB) shall consider the design, installation, and operating conditions and unit-specific historical documents. This evaluation should consider:
(a) area temperature at closing and opening, not applicable if insulated.
(b) fluid temperature at closing.
(c) upstream and downstream temperature at opening, not applicable if not insulated.
(d) Valve insulation should be considered.

5.4.4 Perform TB evaluations for each gate valve not eliminated from TB susceptibility and document the results in the Pressure Locking Thermal Binding Evaluation form.

(1) T2-Is the valve closed with a hot process fluid for other gates above the and then opened after the valve has cooled.
(2) T3-Is the valve closed cool but later heated and then allowed to cool prior to opening.
(3) T4-Is the valve closed cool but later subjected to process fluid differential heating prior to opening.

PRESSURE LOCKING AND THERMAL BINDING SUSCEPTIBILITY

5.5 Gate Valve Pressure Locking Susceptibility Evaluation

Section P of the form in Appendix A shall be used to document the review of pressure locking susceptibility

5.5.1 If solid wedge, skip pressure lock evaluation due to rapid depressurization (P5)

5.5.2 Evaluation of a gate valve's potential susceptibility to PL shall be based upon the following assumptions.

(1) Valve bonnet cavity completely filled with fluid.

(2) Valve, bonnet to body seal, and stem packing is leak tight.

(3) Check valves and other system boundary valves leak into piping volume containing valve.

(4) Valve body, bonnet, stem, or disc/wedge orientation does not effect PL.

(5) Industry data and experience (e.g., NUREG-1275 and GL 89-10 Supplement 6) indicates that the following systems (BWR and PWR) have been involved in PL incidents. Careful comparison of similar-like unit specific systems is required:

- low pressure coolant injection (LPCI) and low pressure core spray (LPCS) system injection valves;
- core spray injection(CS) valves;
- suppression pool suction valves;

(6) There is no minimum pressure threshold for PL occurrence.

(7) Valves that have been installed in systems with a process fluid containing compressible gases or fluid/gas mixture other than steam providing the system is not initially filled with water can be excluded from PL susceptibility. Steam service operating conditions are not a basis for exclusion.

Note: Steam systems with isolated flow may condense allowing fluid to enter the bonnet cavity depending on the system and valve configuration. If any of the following statements are true, there is a potential for fluid to enter the bonnet:.

- The valve in a system low point.
- The valve in a horizontal pipe run and the actuator is installed other than vertical.
- The valve in a vertical pipe run is below horizontal.

(8) Pump flow or other pressurization situations can push the upstream disc/wedge off the seat, create a credible flow path into the bonnet cavity, and pressurize it to highest line pressure. Upon removal of upstream pressure, the disc immediately reseats leak-tight.

5.5.3 Evaluation of a gate valve's susceptibility to pressure locking (PL) shall consider the following design, installation, and operating conditions and unit-specific historical documents. This evaluation should consider:

(a) Upstream and downstream pressures at opening.

(b) Maximum upstream pressure prior to opening

(c) Fluid media.

PRESSURE LOCKING AND THERMAL BINDING SUSCEPTIBILITY

5.5.4 Perform PL evaluations for each gate valve not eliminated from PL susceptibility and document the results in the Pressure Locking Thermal Binding Evaluation form.

(1) P2-Does the valve contain a compressible gas or can not be filled with liquid? If so exclude from pressure locking susceptibility.
(2) P3-Is the valve susceptible to fluid entering the bonnet cavity? If so continue.
(3) P4-Is the valve closed cold and opened at a higher process temperature? or
(4) P5-Is the valve subjected to high system pressure and opened after sudden depressurization? If so evaluate/document the MOV capability.
(5) P6-Is the valve closed cold and opened from full closed at a higher ambient temperature? Does the valve bonnet temperature increase during the accident and prior to opening the valve? If so quantify the temperature transient and evaluate/document the MOV capability

5.6 Documenting the Results

The results of the PLTB evaluation shall be documented in a Engineering Analysis or an equivalent vendor calculation/report. The completed Pressure Locking Thermal Binding Evaluation form serves as a documentation summary of the evaluation of pressure locking and thermal binding, and shall be included in the Engineering Analysis as described above for each valve. Additional text, including a list of assumptions, design inputs and supporting analysis shall be documented in the Engineering Analysis.

5.7 Corrective Actions and Preventative Measures

Once a valve has been determined to be susceptible to PL and/or TB, appropriate action must be taken. This consists of two parts: 1) Evaluation of the MOVs operability, and 2) Determine the suitability of the MOV to meet design specifications. Methodologies are presented below to address both parts. The options presented have both advantages and limitations which must be carefully reviewed prior to selecting the most appropriate option.

5.7.1 Operability Determination for Pressure Locking

(1) Determine the maximum bonnet pressure of the subject MOV at opening. This can be from a pressure source, internal or external heating, or a combination of both. Document the basis for these pressures.
(2) Determine the minimum upstream and downstream pressures at opening.
(2) Determine the additional thrust required to open the valve in the pressure locked condition, and evaluate the motor actuators capability to overcome the additional load due to PL.
(3) If the actuator capability is greater than the estimated thrust required to open the valve it can be considered operable. If not, evaluation of the intended safety function and the possibility of operator action should be considered. Is should be noted that manual operation may not open the valve with out cooling the valve or loosening the packing to provide a vent path. Also, consideration of the structural capability of the valve, such as disc ears, should be considered.

PRESSURE LOCKING AND THERMAL BINDING SUSCEPTIBILITY

5.7.2 Design Resolution of Pressure Locking

(1) Currently, the equations available for the calculation of opening forces have very limited testing to validate them. As a design solution, analysis would have to be supported by testing on a similar valve.

(2) Physical modifications and changes to control system logic provide ways to prevent Pressure Locking, but each has their limitations:
   (a) As appropriate, drill a small hole in one side of the disc to relief bonnet pressure. The makes the valve leak tight in only one direction.
   (b) Install a pressure relief or vent valve in the valve bonnet or body. This requires external components and/or operator action.
   (c) Install an external bypass line with a manual valve from the bonnet to the high pressure side of the valve. This provides the ability to maintain sealing capability in both directions, but requires operator action.

5.7.3 Operability Determination for Thermal Binding

(1) There are no generally accepted analytical methods to calculate the amount of thrust required to overcome thermal binding. Therefore it must be assumed the actuator will not be able to open the valve.

(2) Operator action, unless credit can be given to heat the valve back up to it's initial temperature, likewise cannot be credited to open the valve.

5.7.4 Design Resolution of Thermal Binding

(1) Success in eliminating TB has been achieved by procedural changes to require cycling the valve out of its seat periodically during system cool down. This should be accomplished at every 50°F change in temperature.

(2) Replacement of valves with parallel sliding gate valves that are not susceptible to thermal binding.