UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2

DOCKET NOS. 50-325/324

RELATED TO DEMONSTRATION OF CONTAINMENT PURGE AND VENT VALVE OPERABILITY

1.0 Requirement

Demonstration of operability of the containment purge and vent valves, particularly the ability of these valves to close during a design basis accident, is necessary to assure containment isolation. This demonstration of oper ability is required by BTP 6-4 and SRP 3.10 for containment purge and vent valves which are not sealed closed during operational conditions 1, 2, 3, and 4.

2.0 Description of Purge and Vent Valves

The valves identified as containment isolation valves in the purge and vent system are as follows:

Valve Number	Size (Inches)	Use	Location
CAC-V6	18	Drywell - Purge	Outside Containment
CAC-V9	18	Drywell - Vent	Outside Containment
CAC-V5	20	Suppression Pool - Purge	Outside Containment
CAC-V7	20	Suppression Pool - Vent	Outside Containment
CAC-V4	8	Main Inlet-Purge	Outside Containment
CAC-V8	20	Suppression Pool-Vent	Outside Containment
CAC-V10	18	Drywell-Vent	Outside Containment
CAC-V15	24	RB Vent	Outside Containment
CAC-V49	4	Drywell-Vent	Outside Containment
CAC-V50	4	Drywell-Vent	Outside Containment

All of these valves manufactured by Posi-Seal International, are Class 150 as described in Posi-Seal Technical Bulletin Number 1A. The actuators are Bettis Robotarm air to open, spring return models. The actuator model numbers used for the 4-inch valves are CB415-SR80, those for the 8-inch valves are CB520-SR80, and all other valves use model number 732C-SR80.

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3.0 Demonstration of Operability

The following documents were examined for this review:

A. Letter of January 19, 1977 from E. E. Utley of the Carolina Power and Light Company to T. A. Ippolito, ORB3, U.S. Nuclear Regulatory Commission.

B. Letter of May 1, 1979 from E. E. Utley of the Carolina Power and Light Company to T. A. Ippolito, ORB3, U.S. Nuclear Regulatory Commission.

C. Letter of November 19, 1979 from E. E. Utley of the Carolina Power and Light Company to D. G. Eisenhut, DOR, U.S. Nuclear Regulatory Commission.

D. Letter of November 17, 1981 from E. E. Utley of the Carolina Power and Light Company to T. A. Ippolito, ORB2, U.S. Nuclear Regulatory Commission with:

Attachment 1 - Valve Sizing Calculations
Attachment 2 - Seismic Calculations.

E. "Effect of Fluid Compressibility on Torque in Butterfly Valves," ISA Annual Conference, ISA Transactions, Vol. 8, No. 4, pg. 28, 1969.

F. Letter of December 22, 1983 from Carolina Power and Light Company (P. W. Howe) to the U.S. Nuclear Regulatory Commission (D. B. Vassallo), additional information.

G. Letter of February 29, 1984 from the Carolina Power and Light Company (P. W. Howe) to the U.S. Nuclear Regulatory Commission (D. B. Vassallo), reference Posi-Seal International, Inc., valve(s) analysis.

Reference A indicates that the licensee plans to justify unlimited use of the plants purging system.

Reference B states that the drywell peak pressure due to the design basis Loss of Coolant Accident (LOCA) for the Brunswick plant is 49.4 psig, and indicates that the purge valves are designed to "operate" at 62 psig.

Reference C indicates that the licensee intends to verify operability by analysis.

Reference D transmits the analyses made by the valve manufacturer and contains most of the technical information used in this review.

Reference E describes a method for predicting aerodynamic torque using torque relationships developed for incompressible flow.

Reference F responds to a NRC letter dated December 1, 1983 requesting additional information.

Reference G transmits the Posi-Seal LOCA and seismic analysis with accompanying piping schematics, dated February 15, 1984 - Report Number 32525 $L-001.

Note: The applicant, Carolina Power and Light Company (CP&L) has mechanically limited all valve openings to less than 50° (90° = full open).

3.1 A conservative factor used in the detailed analysis (Reference G) by Posi-Seal is a constant, 49.4 psig differential pressure across the valve with no credit taken for the LOCA containment pressure ramp. When a LOCA occurs, the pressure inside the drywell increases to 49.4 psig (64.1 psia) and the temperature increases to 310°F. An analysis was performed on an 18-inch valve (V6) for both a nitrogen and steam media. Since nitrogen resulted in the larger aerodynamic forces (higher torques) all the valves were analyzed assuming nitrogen as the fluid media. The torques resulting from a DBA/LOCA for all the valves were determined for both the preferred flow direction (tend to assist valve closing) and the nonpreferred direction (can resist valve closing). In the actual plant installation, two of the valves are installed in the nonpreferred flow direction, the 20-inch (V8) and the 24-inch (V15) valves.

3.2 Using the computer program "FLOW-CL," closing times of all the valves were calculated for no flow, flow in the preferred direction and flow in the nonpreferred direction.

3.3 The "FLOW-CL" program, which is based on model test data from testing performed by Posi-Seal, calculates various torques versus incremental 10° valve closure angles. Aerodynamic torques for angles other than the 10° disc closure angle increments were also calculated since density, pressure drop, and velocity are more linear, between the 10° increments than is the aerodynamic torque.

The licensee's stress analyses (Reference G, Appendix E) assumes a coincident LOCA and seismic event, and is performed for flow in both the preferred and non-preferred directions.

Calculations were based on the valves having urethane seals (original valve equipment). Seating torques for the urethane seals are higher than for the Tefzel seals, which are the seals these valves are presently equipped with. Using the higher seating torque value adds conservatism to the approach.

3.4 The influences of an upstream bend, tee, or another valve were stated as being investigated relative to their effect on valve aerodynamic torques. Schematics of the piping systems with accompanying computer printouts for the determination of flow conditions for each valve were presented for preferred and nonpreferred flows (10° incremental openings, from 10° to 90°, at a ΔP across the valve of 49.3 psid, maximum drywell or suppression pool pressure).

3.5 In the determination of aerodynamic torque effects and stresses on the valve assembly during LOCA conditions, Posi-Seal International, Inc. developed computer programs which modeled the piping system, ascertained flows at various valve angles, and simulated actuator stroking of the valve from fully opened (90°) to fully closed.

3.6 In order to simulate the closing times of the valve by the actuator stroking, an equation which describes the torques acting on the valve stem was defined by Posi-Seal:

$$T_{TTD} = T_{Flow} + T_{Air} + T_{Spring} + T_{Packing\ and\ Seal} + T_{Bearing}$$

where:

T_{TTD} = the net torque tending to open the valve (equals zero when the valve starts to close)

T_{Flow} = the torque due to aerodynamic flow caused by the LOCA

T_{Air} = Actuato: :orque (air position) tending to open the valve

T_{Spring} = the torque due to the actuator spring tending to close the valve

$T_{Packing\ and\ Seal}$ = the torque due to the packing and the seal (resisting closing from 3° of fully closed for the seal). The running torque of the packing is ≈ .6 times the break away torque.

$T_{Bearing}$ = the torque due to the valve ΔP forcing the stem/disc assembly into the bearings.

3.7 The analysis evaluating the air-open, spring-close actuators considered the forces acting on the Scotch Yoke Pin. Also considered was the flow through the solenoid valve or quick exhaust of the actuator air. The equation for determining this (Q) is as follows:

Q = flow through solenoid valve or quick exhaust.

$$= \frac{963\ C_{VS}\ F_{LS}\ P_1 \sqrt{1 - 25\ (F_L)^2}}{\sqrt{GT}}$$

where:

C_{VS} = C_V of solenoid valve or quick exhaust (C_V = valve coeffient)

F_{LS} = rated fluid pressure recovery factor of a solenoid valve or quick exhaust = .9

G = specific gravity of air = 1

T = temperature degree Ranking = Assume equals 530°

P_1 = pressure of the air in the piston cylinder.

3.8 The seismic analysis (Reference G, Posi-Seal report) performed for the valve/actuator assemblies considered longitudinal, vertical, transverse, and lateral-disc/stem natural frequencies. Additionally, valve stresses for actuator/bracket bolting, bracket, bracket/valve bolting, valve neck, valve stem and valve disc pin were analyzed. Other factors addressed in the overall seismic analysis were valve and piping section modulus, deflections, valve body bolting, and the influence of a bend, tee and/or a valve upstream. The disc/stem natural frequency was calculated for the worst case, that being the valve open where the disc is not supported by the seat. In addition to determining component spring rates, operating and seismic stresses for LOCA conditions were established. This analysis determined that all the valves would operate satisfactorily within the limited 0° to 50° valve disc excursion.

4.0 Evaluation

4.1 Posi-Seal derived an acceptable way to correlate their torque testing data, which was based upon hydrodynamic (water) tests, to air and steam. An assumption was made by Posi-Seal which stated that drag and lift coefficients (C_D, C_L) and length center line stem to resultant lift and drag forces (L_D, L_L), are the same for the same size and class valve, assuming the same angular position, regardless of fluid, flow media, or temperature. Tests in Reference E have shown that at low pressure drops across a butterfly valve, the torques due to lift and drag effect are essentially equal for compressible and incompressible flow. However, for pressure drops of the order of 40 psi (which is the case at the 50° maximum opening for all these valves, i.e., 39.72 to 44.49 psid, the only exception being the 8-inch (V4) valve which was 4.69 psid), the resultant torque is approximately 25% less for compressible flow. Therefore, the torques determined in the "FLOW-GL" computer program for every 10° of valve closure during a LOCA, are conservative.

4.2 In the determination of the effects of an elbow just upstream of the 20-inch (V5) butterfly valve on valve/actuator aerodynamic torque loading and stresses, Posi-Seal has stated that the effect will be minimal since the valve stem is in the same plane, and the flow will pass evenly on either side of the stem; consequently, not imposing an additional aerodynamic torque. In fact, Posi-Seal further states that for this elbow configuration, the torque will be less than for a straight pipe inlet, since the flow resultant will not pass over the center of the disc where the airfoil effect of the disc is the greatest. Laboratory test information available from other valve manufacturers indicate that for a butterfly valve having an elbow just upstream and its disc shaft in-plane with the elbow (elbow-shaft in-plane) the coefficient of torque* (C_T) will be greater than 1.0 when compared to a straight pipe inlet to the valve. These data also determined that for an elbow-shaft out-of-plane configuration, the C_T is greater than 2.0 in some instances.

Our investigation has determined that with the restricted 50° openings, there is a torque safety margin greater than 1.5. Additionally, we have recognized that for the V5 valve, the upstream elbow is 60° rather than 90° which adds an additional conservative factor. We find the licensee has satisfactorily demonstrated valve operability for the restricted 50° valve opening configuration.

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*C_T is the torque coefficient determined from test data, reference the standard dynamic torque formula for butterfly valves: $T_D = C_T \times D^3 \times \Delta P$ where:

T_D = dynamic valve torque in in/lbs
ΔP = total pressure drop measured across valve (psi)
D = valve bore diameter (ft).

4.3 For a piping configuration where two butterfly valves are in series such as the 18-inch (V10) and the 20-inch (V8) valves, Posi-Seal stated they added a safety factor, because they did not know how to accurately predict the velocity profile of flow as it comes out of an open valve. Since the straight pipe lengths between the valves into the V10 and V8 valves are 1.0 pipe diameter and 1.2 pipe diameters, respectively, the upstream flow effects could be significant. As an example, other valve manufacturers tests on this piping configuration have disclosed that worst case torque occurred at 2.0 diameters downstream of the first valve and diminished to results approaching single valve straight pipe test at 4.0 diameters.

We agree with Posi-Seal in that they were correct in introducing a safety factor. Our investigation has determined that with the restricted 50° valve openings, there is a torque safety margin greater than 1.5. We find the licensee has satisfactorily demonstrated valve operability for the restricted 50° valve opening configuration.

4.4 Seismic qualification for the containment purge and vent valves has been addressed by the licensee in the Posi-Seal report dated February 29, 1984 (Reference G, Appendix E).

5.0 Summary

5.1 We have completed our review of the information submitted to date concerning operability of the 4, 8, 18, 20, and 24-inch valves used in the containment purge and vent system for the Brunswick Steam Electric Plant, Units 1 and 2. We find that the information submitted has demonstrated that these valves have the ability to close from the mechanically limited opening positions of 50° in the event of a DBA/LOCA containment pressure buildup. Paragraphs 4.1, 4.2, and 4.3 are the basis for this determination.