UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
FLORIDA POWER AND LIGHT COMPANY
ST. LUCIE PLANT, UNIT NO. 1
DOCKET NO. 50-335

DEMONSTRATION OF CONTAINMENT PURGE AND VENT VALVE OPERABILITY

1.0 Requirements

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 operability is required by BTP CSB 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

Valve Number	Unit	Valve Size (Inches)	Use Exhaust/Supply	Location
FCV-25-1	1	48	Supply	Outside
FCV-25-2	1	48	Supply	Inside
FCV-25-3	1	48	Supply	Inside
FCV-25-4	1	48	Exhaust	Inside
FCV-25-5	1	48	Exhaust	Inside
FCV-25-6	1	48	Exhaust	Outside

The subject valves are butterfly-type model R1A offset asymmetric disc 48 inch, manufactured by the Henry Pratt Company. These valves are equipped with a pneumatic operator, air open-spring close, Model Number T520-SR2 manufactured by the G. H. Bettis Company. There is no accumulator air supply used and no manual hand wheel provided.

The valve opening angles are presently limited to 40° (90°=full open). Limit switch and pilot valve information were not presented.

3.0 Demonstration of Operability

3.1 Florida Power and Light Company (FP&L) has provided operability demonstration information for the containment purge and vent system isolation valves used at their St. Lucie Unit 1 station in the following submittals:

Reference A - FP&L letter, July 15, 1983, Robert E. Uhrig to Robert A. Clark (NRC).

Reference B - FP&L letter, March 31, 1983, Robert E. Uhrig to Robert A. Clark (NRC).

Reference C - FP&L letter, December 9, 1980, Robert E. Uhrig to Robert A. Clark (NRC).

Reference D - FP&L letter, February 6, 1980, Robert E. Uhrig to Robert A. Clark (NRC).

Reference E - FP&L letter, December 13, 1979, Robert E. Uhrig to R. W. Reid (NRC).

Reference F - FP&L letter, November 29, 1979, Robert E. Uhrig to R. W. Reid (NRC).

Reference G - FP&L letter, May 25, 1979, Robert E. Uhrig to R. W. Reid (NRC).

Reference H - FP&L letter, February 1, 1979, Robert E. Uhrig to R. W. Reid (NRC).

Reference I - FP&L letter, January 5, 1979, Robert E. Uhrig to R. W. Reid (NRC).

Reference J - FP & L letter, August 6, 1984, J. W. Williams, Jr. to James R. Miller (NRC).

3.2 FP&L's determination of the structural and operational adequacy of the subject valves is based upon a April 27, 1983 Pratt report combining model tests and static analysis. The model testing considered alternate valve/ piping configurations such as an elbow upstream of the valve with the valve shaft "out-of-plane" with respect to the elbows. Also considered were the consequences of flow from the valve disc's flat and arched sides, clockwise and counter clockwise disc closure, and various disc diameter to thickness ratios. The analysis consisted of a static analysis of the valve components to determine whether the stress levels, under combined seismic and LOCA conditions, were less than code allowable stresses and/or 0.40 times yield strength for shear (non-code components).

3.3 A valve operator evaluation was presented based on the operator manufacturer's rating versus the calculated LOCA-induced fluid dynamic torques.

3.4 The valve torque loads were determined to be the summation of fluid dynamic torque (T_D) and bearing friction torque (T_B) at any disc angle. The equations number 1 (bearing friction torque) and number 2 (fluid dynamic torque) were used.

Equation 1 - Bearing Friction Torque

$$T_B = P \times A \times U \times \frac{d}{2}$$

where:

P = pressure differential, psi
A = projected disc area normal to flow, in^2
U = bearing coefficient of friction
d - shaft diameter, in.

Equation 2 - Fluid Dynamic Torque

For subsonic flow $[R_{CR} > P_1/P_2 > 1.07 \text{ (approx.)}]$

$$T_D = D^3 \times C_{T1} \times P_2 \times \sqrt{K/1.4} \times F_{RE}$$

For sonic flow $[P_1/P_2 \geq R_{CR}]$

$$TD = D^3 \times C_{T2} \times P_2 \times \sqrt{K/1.4} \times F_{RE} \quad (F_{RE} \geq 1)$$

where:

T_D = fluid dynamic torque, in-lbs
F_{RE} = Reynold number factor
R_{CR} = critical pressure ratio, (f[α])
P_1 = upstream static pressure at flow condition, psia
P_2 = downstream static pressure at flow condition, psia
D = disc diameter, in.
C_{T1} = subsonic torque coefficient
C_{T2} = sonic torque coefficient
K = isentropic gas exponent (≈1.2 for air-stream mix)
α = disc angle, such that 90 = fully open; 0 = fully closed.

It was noted in the FP&L submittal that C_{T1} and C_{T2} are a function of disc angle, an exponential function of pressure ratio, and are adjusted to a 5 inch test model using a function of Reynolds number.

Torque coefficients and exponential factors are derived from an analysis of experimental test data and correlated with analytically predicted behavior of airfoils in compressible media.

3.5 The Pratt report observed that empirical and analytical findings confirm that subsonic and sonic flow conditions across the valve disc have an unequal and opposite effect on dynamic torque. Specifically, increases in upstream pressure in the subsonic range result in higher torque values, while increasing P_1 in the sonic range results in lower torques. Therefore, the point of greatest concern is the condition of initial sonic flow, which occurs at the critical pressure ratio.

3.6 The report also recognizes the effect on valve loads during the transition from subsonic to sonic flow, which greatly amplifies the resulting torques. In fact, the maximum dynamic torque occurs with initial sonic flow at a valve angle of 70° open.

3.7 The FP&L submittal also incorporated the NRC guidelines for demonstration of operability of purge and vent valves, dated September 27, 1979.

3.8 A flow time history was presented for the worst case valve closing. The following tabulation shows those parameters critical for demonstrating purge and vent valve operability for the 48-inch R1A class 75 butterfly valve from the 40° open position.

Valve Angle (°)	Flow (lb/min)	T_D* (inch-lbs)	Time (LOCA) (Seconds)
40	14094	98358	2.3**
35	10566	75956	2.73
30	8314	46882	3.09
25	5873	32432	3.33
20	3567	22990	3.41
15	1978	9442	3.50
10	1001	5529	3.74
5	315	4055	4.10
0	0	33877	4.52

*The dynamic torque (T_D) figures include seating (at 0°) bearing, and hub seal torques.
**The 2.3 seconds at 40° consists of an 0.8 second instrumentation time and a 1.5 second response delay time.

A valve operator study was also performed for valve closure from a 45° and a 50° valve opening and resulted in excessive operator loadings.

3.9 The FP&L submittal for the valve stress analysis consisted of two major sections: (1) the body analysis and (2) all other components. The body analysis was as per the rules and equations given in paragraph NB 3545 of Section III of the ASME Boiler and Pressure Vessel Code. The other components are analyzed per a basic strength of materials type of approach. For each component, tensile and shear stress levels are calculated and are then combined (Ref. Equation 3 as follows):

Equation 3

$$S_{MAX} = 1/2\ (T_1 + T_2) + 1/2\ \ (T_1 + T_2)^2 + 4\ (S_1 + S_2)^2$$

where:

S_{MAX} = maximum combined stress (psi)
T_1 = direct tensile stress (psi)
T_2 = tensile stress due to bending (psi)
S_1 = direct shear stress (psi)
S_2 = shear stress due to torsion (psi).

3.10 The FP&L seismic stress analysis submittal utilized the maximum valve torque resulting from LOCA conditions, combined with simultaneously applied 3-axis "G" loads in accordance with the design specification. Valve orientation with respect to gravity is taken into account by adding the

appropriate quantity to the seismic loads. The structural analysis was for the valve/operator assembly and the main elements of the butterfly valve, in accordance with paragraph NP 3550 of Section III of the ASME Boiler and Pressure Vessel Code (Class 1).

3.11 The Bettis T520-SR2 operator is described as having a rating of 200,000 in-lbs at full open and closed positions only. It is rated at 143,744 in-lbs at 68° valve angle and 125,000 in-lbs at 45° (minimum rating). This is compared to the maximum valve dynamic torque of 98,358 in-lbs (valve blocked at 40°).

4.0 Evaluation

4.1 The assumptions used by the licensee in the analysis from which the dynamic torques, during a DBA/LOCA, as predicted are conservative:

A. No load closure time including delay time used for the analysis. Actual closure time under the postulated accident conditions will be less since the dynamic torques assist in valve closure.

B. Flow towards the hub side of the offset asymmetrical disc was assumed in the calculations (highest torques)

C. Inlet pressure to the valve assumed constant, and taken at the time of full valve closure from the LOCA containment pressure response curve.

D. Single valve closure with no credit taken for downstream pressure losses.

4.2 The staff has reviewed the dynamic torques (T_D) determined by the model tests, and in all cases they were lower than those calculated by the Pratt purge valve analysis program.

Verification was provided in the letter of August 6, 1984 (Reference J) confirming that the model valve test data was based on the R1A valve/disc assemblies installed at St. Lucie 1, correlating the data from Pratt Model 1200 series valve/disc assembly test with the St. Lucie 1 valve assemblies presented.

4.3 The staff has reviewed the static analysis of the valve components used in determining the stress levels under combined seismic and LOCA conditions. These analyses showed the stresses to be less than code allowables for the materials utilized. The valve components having the smallest safety factor the adjusting screw threads. The calculated shear stress was 9527 psi versus the ASME allowable stress level of 9960 psi. The staff finds these analyses acceptable.

4.4 With regard to valve sealing integrity, the staff accepts the licensee's contention that molded EPT seats are generically known to have a cumulative radiation resistance of 1×10^8 rads at a maximum incidence temperature of 350°F. FP&L intends to visually inspect the seats every 18 months and replace them as required.

4.5 The Bettis Model T520-SR2 operator was determined by analysis to be structurally suitable to withstand combined LOCA and seismic loads when blocked to a maximum opening angle of 40° from the closed position. Model valve test data was used for this analysis also, and it was confirmed in the August 6, 1984 letter that the model valve data upon which it was based is representative of the R1A valve/disc installed in St. Lucie 1. The staff finds this analysis acceptable.

5.0 Summary

5.1 The staff has completed its review of the information submitted concerning operability of the 48-inch containment purge and vent valves for St. Lucie Unit 1 and finds that the information submitted demonstrates that these valves have the ability to close against the buildup of pressure in the event of DBA/LOCA from the blocked 40° position.