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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

MONTICELLO NUCLEAR GENERATING PLANT

DOCKET NO. 50-263

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 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 of Purge and Vent Valves

Valve Number	Valve Size (Inches)	Use	Valve Actuators Air Vent Locations
AO-2377	18	Primary containment supply	Outside containment
AO-2378	18	Torus supply	Outside containment
AO-2381	18	Primary containment supply	Outside containment
AO-2383	18	Torus exhaust	Outside containment
AO-2386	18	Primary containment exhaust	Outside containment
AO-2387	18	Primary containment exhaust	Outside containment
AO-2896	18	Torus exhaust	Outside containment

The subject valves are butterfly-type Model 9210, inflatable T-ring, and are manufactured by Fisher Controls Company. The valve actuators are the air to open-spring to close diaphragm type Model Number 656-60 and are also manufactured by Fisher Controls Company. These valves are limited to a 40° opening angle (90° = full open) by means of a pin-type stop.

3.0 Demonstration of Operability

3.1 The Northern State Power Company (NSPCo) has provided operability demonstration information concerning the purge and vent valves for their Monticello Nuclear Generating Plant in the following submittals (References):

A. September 14, 1984 teleconference - D. Musolf (NSP) to P. Turtzo and B. Miller (BNL).
B. June 25, 1984, letter from D. Musolf (NSP) to Director, Office of Nuclear Reactor Regulation (NRC).
C. June 15, 1984, letter from D. Musolf (NSP) to Director, Office of Nuclear Reactor Regulation (NRC).
D. June 4, 1984, letter from D. Musolf (NSP) to Director, Office of Nuclear Reactor Regulation (NRC).

E. April 19, 1984, letter from D. Musolf (NSP) to Director, Office of Nuclear Reactor Regulation (NRC).
F. April 19, 1982, letter from D. Musolf (NSP to H. Nicolaras (NRC).
G. January 5, 1982, telecopy from M. Haughey (NRC) to T. Restivo (BNL).
H. November 14, 1979, letter from L. Mayer (NSP) to Director, Office of Nuclear Reactor Regulation (NRC).
I. June 7, 1979, letter from L. Mayer (NSP) to Director, Office of Nuclear Reactor Regulation (NRC).
J. January 3, 1979, letter from L. Mayer (NSP) to Director, Office of Nuclear Reactor Regulation (NRC).

3.2 The Fisher valve analysis (Reference C) has incorporated the following conservative assumptions:

- o Single valve closure is assumed.
- o No credit is taken in the analysis for downstream pressure losses.
- o Peak LOCA containment pressure (56 psid) is assumed during valve closure.

3.3 Dynamic Torque (T_D) predictions stem from coefficients developed by bench tests on model valves with similar disc configurations and flow characteristics. A series of water flow tests were conducted with a group of 4-inch and 6-inch valves. Analytical techniques involving scaling are used to determine T_Ds for the actual valve sizes. The basis followed by Fisher in using incompressible (water) flow model tests to establish dynamic torque coefficients applicable to large diameter valves in compressible flow service is presented in the I.S.A. paper entitled "Effect of Fluid Compressibility on Torque in Butterfly Valves." These bench tests were conducted using the Fluid Controls Institute (FCI) specifications for test arrangement and conduct.

Fisher Controls Company has determined that the valve disc shaft was the most critically stressed valve component. The subject valve assemblies were modified with new 17-4PH shafts, taper pins and elastomers (T-rings and O-rings for the bodies). In the analysis, Fisher Controls Company evaluated various locations along the valve disc shaft, and the resulting computer data was submitted for review. This data determined the maximum actuator torque requirements and the maximum allowable ΔPs for each 10° incremental valve disc position.

Fisher's approach to evaluating critical valve parts in this valve design is to determine maximum allowable ΔPs across the valve at a given disc angle. This maximum allowable ΔP is based on the valve's weakest operating part, but does not include the operator and associated mounting hardware. The maximum allowable ΔP for each disc angle (10° increments) is compared to the LOCA peak containment pressure. From this, the maximum disc-opening angle is selected.

The Fisher-developed computer program used to establish the maximum opening angle is described as follows:

- o For a given valve at some angle of opening, the program begins by calculating the loading. This includes a hydrostatic load on the disc, seating torque, bushing, and packing torque, and dynamic torque.

- o After the loading is determined, the program calculates stresses in the shaft, key, pin, and bushing for a specific ΔP and compares these stresses to the code allowable stresses. This stress is based on 1.5 x "S." "S" is the allowable stress figure found in Section III of the ASME Boiler and Pressure Vessel Code. "S" is equal to 1/4 of the minimum tensile strength or 2/3 of the minimum yield strength, whichever is less. For shear stresses, 0.75 "S" is used as an allowable.

- o The program calculates stress and changes ΔP iteratively until the allowable stress matches the calculated stress. This determines the maximum allowable pressure drop for that angle of opening based on the stress at a single point. This process is done for cases 1, 2, 3, 4, and 5 (as defined below) for each angle of opening.

  Case 1 - Stress in the shaft at the disc hub due to bending and torsion.
  Case 2 - Stress in the shaft at the disc hub due to torsion and traverse shear.
  Case 3 - Stress at the pinned disc-shaft connection.
  Case 4 - Stress at the keyed actuator-shaft connection.
  Case 5 - Stress at the shaft bushing.

3.4 The valve actuator was treated by Fisher Controls Company as a single component capable of handling torques less than or equal to the maximum rated actuator output (5,773 in-lbs). The valve torque loads are determined using the computer program mentioned above in Section 3.3.

Fisher Controls Company recommended that the subject purge and vent valves be limited to the 40° maximum angle opening, since at angles over 40° open, the torque level exceeds the maximum actuator output of 5,773 in-lbs (Reference C, enclosed Fisher letter dated December 4, 1981).

3.4.1 The following tabulation (Table 1) was taken from the referenced document in Section 3.4 above, and defines the required actuator torques at angles from 0° to 50° and a constant ΔP of 56 psid from 10° to 50° (62 psid at 0°).

3.4.2 Fisher Controls Company has shown that from the 40° open valve disc position to valve closure the dynamic torque developed (for both flow into hub and into flat) will tend to close the valve (Reference C, page 16 and Attachment 5). Only ~836 in-lbs of torque is needed at the 40° open angle to overcome frictional effects.

Table 1

Valve Position (Open Angle)	Allowable ΔP (psid)	Required Operating Torque (in-lbs)	Gas Flow Coefficient (Cg)
0°	62	1,579	0
10°	56	2,685	4,B09
20°	56	3,233	11,884
30°	56	2,780	29,963
40°*	56	4,990	54,700

*Maximum opening.

The actuator spring compression torque ranges from ~2,395 in-lbs at 0° to ~4,444 in-lbs at 40° open, with a 30 psig actuator air supply. Note: Dynamic flow effects tend to close the valve or have a neutral effect on the opening torques in the opening range of interest (0°-40°) (Reference C, enclosed Fisher letter dated December 4, 1981).

3.5 To account for those valves with an upstream elbow, the following Table 2 was taken from the NSPCo submittal, Reference C, (enclosed NUTECH report dated April 9, 1982).

Table 2

Valve Number	Distance, Elbow to Valve		Valve Shaft to Elbow		Flow Into	Effect on Valve Closure
	Inches	Diameter	In-plane	Out-of-plane		
AO-2377	68.4	3.9	X		Flat	*
AO-2378	20.0	1.14		X	Flat	Assist closure
AO-2381	66.25	3.8	X		Flat	*
AO-2383	15.5	.88	X		Hub	*
AO-2386	40.0	2.3		X	Flat	Assist closure
AO-2387	61.0	3.5		X	Flat	Assist closure
AO-2896	49.5	2.8	X		Hub	*

*Effect not give in NSPCo submittal tabulations.
Some orientation changes of the valves in Table 2 are expected (Reference C, cover letter)+

+In a telephone call on January 15, 1985, Northern States Power Company representatives stated that all the subject valves were reoriented to the elbow-shaft in-plane configuration, with flow from containment to the flat side of the valve disc during the 1984/85 piping replacement outage.

For those valves with elbow-shaft in-plane installations, NSPCo has determined that the Monticello plant layout is such that a non-uniform fluid profile is not expected to produce any additional torque on the valve disc (Reference C, enclosed NUTEH report, dated April 9, 1982 attachment).

For those valves with elbow-shaft out-of-plane installation configurations,* NSPCo has determined that this orientation occurs only with flow into the flat. Accordingly, they state that since peak operator torque occurs when flow is into the hub (which is the valve qualified orientation) the peak torque they will experience is equal to 0.66 times these calculated maximum torques. Example: 0.66 x 4,990 = 3,293 in-lbs at 40° for flow into the flat. In the development of the dynamic torque coefficients, a factor of 1.5 was used when a flow into the hub configuration was evaluated, as compared to a flow into the flat side of the disc.

4.0 Evaluation

4.1 Fisher's T_D predictions stem from model valve bench tests which utilize straight pipe inlet configurations to establish uniform approach flow.

The testing accounted for flow direction, i.e., flow into the hub side of the disc versus into the flat side. The tests showed that the T_D values are 1.0 to 1.5 higher when flow is into the hub side. For purposes of conservatism and convenience, Fisher uses a factor of 1.5 times T_D (flat side) to establish the T_D loads used in their stress analysis.

The Fisher tests did not include inlet piping configurations involving elbows and therefore their effect on T_D cannot be quantified for those Monticello valves affected by nonuniform flow off of an upstream elbow.

To account for those valves with elbow-shaft in plane installation configurations, relative to T_D prediction, NSPCo stated:

> "If it has been determined that plant layout is such that the valve shaft is oriented to be in-plane with the upstream elbows, the nonuniform fluid profile is not expected to produce an additional torque on the valve since both "wings" of the disc (as split by the shaft) will be subject to the same flow with respect to time."

This statement is essentially the same as offered by Fisher for their valve in other plants. Fisher to date has not cited any test data to confirm this.

+In a telephone call on January 15, 1985, Northern States Power Company representatives stated that all the subject valves were reoriented to the elbow-shaft in-plane configuration, with flow from containment to the flat side of the valve disc during the 1984/85 piping replacement outage.

Information available from other valve manufacturers indicate that for a give valve design at the same conditions the ratio of C_T (elbow-shaft in plane) to C_T (straight pipe) is greater than 1.0 and C_T (elbow-shaft out of plane) to C_T (straight pipe) is greater than 2.0 in some instances. Based on limited elbow testing information available, it is believed that where bench tests did not include elbows in the piping, a factor of 1.5 times C_T (straight pipe) for an elbow-shaft in plane configuration and a factor of 3.0 times C_T (straight pipe) for an elbow-shaft out of plane configuration would yield conservative values of T_D.

Accordingly, the use of 1.5 times C_T (straight pipe) to predict T_D developed in in-service valves having elbow-shaft in-plane configurations, and 3.0 times C_T (straight pipe) for valves having elbow-shaft out-of-plane configurations would be acceptable.

However, since the teleconference of January 15, 1985, explaning that all the subject valves are presently being reoriented, as required, to an elbow-shaft in-plane and with the flat face of the disc upstream to containment flow, this evaluation will respond to this new valve orientation.

4.1.1 Based on the above, it was determined that for the elbow-shaft in-plane valves (all subject valves, Reference A), NSPCo has demonstrated that the T_Ds used for the stress analysis are conservative. The flow (LOCA) direction is now described as flowing into the flat face of the disc; therefore, the I.5 factor used to account for flow into the hub effectively serves to increase T_D (flat) sufficient enough to account for the elbow shaft in-plane configurations. Therefore, the operational and structural integrity of these valves are acceptable.

4.2 The maximum allowable actuator output of 5,773 in-lbs (Reference C, attached letter dated March 19, 1981) reflects the design (stress) limitation of the actuator linkage hardware. The determined actuator torques (Table 1) are conservatively based on "flow into the hub," and indicate a maximum torque of 4,990 in-lbs at a 40° open valve position, with a constant ΔP of 56 psid. All the subject valves had shafts in-plane except for the AO-2378 -2386, and -2387 valves, and these three valves have "flow into the flat" installation configurations.

The spring compression torques range from ~2,395 in-lbs at 0° to ~4,444 in-lbs at 40° open. The seating torque required to insure seating (1,578 in-lbs) is quite significantly exceeded by the spring valve torque at 0° of 2,395 in-lbs.

4.2.1 Although the spring torque at 40° (4,444 in-lbs) is less than the required valve operating torque of 4,990 in-lbs, the licensee has shown that for all opening angles from 40° to closing, the dynamic torque developed will tend to close the valve. Based on the above, and the conservative assumptions in the analyses, the actuator and its interfacing hardware are functionally and

structurally adequate for operating the valves from the limited opening angle of 40°.

4.2.2 Stress analysis results presented in Reference C by Fisher Controls demonstrate that the disc to shaft pin connection is the limiting component stresswise with a 50° maximum opening angle (90 = full open). Actuator torque capacity limits the valve opening to 40° and the valves are blocked to a maximum 40° angle.

4.3 Northern States Power states in Reference C that there is no record of seismic qualification analysis on testing other than submission of a shock test report (Test Report Number F607-2420 by Associated Testing Labs, October 11, 1961). Although the staff has no basis to conclude that a seismic event would not prevent these valves from operating on demand, the seismic qualification of these valves is not a part of this task, but will be considered separately on a generic basis.

5.0 Summary

We have completed our review of information submitted concerning operability of the 18-inch valves used in the containment purge and vent systems for the Monticello Nuclear Generating Plant. We find that the information submitted has demonstrated that these valves have the ability to close against the buildup of pressure in the event of DBA/LOCA from the 40° position. Sections 4.1, 4.1.1. 4.2, 4.2.1, and 4.2.2 of the evaluation are the basis for these findings.

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Dated: February 15, 1985