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

SAFETY EVALUATION

SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1

SOUTHERN CALIFORNIA EDISON COMPANY

VENT VALVE OPERATION

DOCKET NO. 50-206

I. BACKGROUND

The results of the staff's review of the San Onofre 1 containment purge/vent system design and operating practices were transmitted to the licensee by letter dated February 17, 1982 (Ref. 1), from D. Crutchfield, NRC, to R. Dietch, Southern California Edison Company (SCECo). The staff's position with respect to purging/venting during operation as presented in the letter is as follows.

1. Purging/venting should be minimized during reactor operation because the plant is inherently safer with closed purge/vent valves (containment) than with open lines which require valve action to provide containment. (Serious consideration is being given to ultimately requiring that future plants be designed such that purging/venting is not required during operation).

2. Some purging/venting on current plants will be permitted provided that:

   a) purging is needed and justified for safety purposes, and

   b) valves are judged by the staff to be both operable and reliable, and

   c) the estimated amount of radioactivity released during the time required to close the valve(s) following a loss-of-coolant accident (LOCA) either

      i. does not cause the total dose to exceed 10 CFR Part 100 Guidelines; then a goal should be established which represents a limit on the annual hours of purging expected through each particular valve, or

      ii. causes the total dose to exceed the guideline values; then purging/venting shall be limited to 90 hours/year.

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3. Purging/venting should not be permitted when valves are being used that are known to be not operable or reliable under transient or accident conditions.

The licensee responded to the staff's request to limit purge/vent operations by letter dated March 27, 1984 (Ref. 2). In this letter, the licensee provided the rationale for why unlimited venting of the San Onofre 1 containment should be allowed to continue. The discussion included an assessment of the potential radiological consequences should a LOCA occur while the vent system is in operation. In a second letter also dated March 27, 1984 (Ref. 3) the licensee provided the evaluation of the operability of the 6-inch vent valves in response to the staff's evaluation of February 6, 1984 (Ref. 4) on this subject.

II. DESCRIPTION OF VENT SYSTEM

The only purge/vent system in operation during normal operation for San Onofre 1 is a 6-inch vent system with redundant butterfly containment isolation valves manufactured by Fisher Controls Company. These isolation valves will automatically close upon receipt of a high containment pressure signal, a safety injection signal, or a high containment radiation signal. The closure times for these valves, including instrument delay time, are less than 15 seconds. The 6-inch containment vent system is used to maintain the containment atmosphere at atmospheric pressure. It has been the standard operating practice at San Onofre 1 to maintain the vent system open continuously to satisfy this purpose. Limiting the use of this system will result in a steady increase in containment pressure, primarily due to instrument air bleed-off and nominal leakage. The vent valves are mechanically limited to an opening of approximately 50° (90° = full open) as discussed in Reference 5.

III. OPERABILITY OF 6-INCH BUTTERFLY VALVES

A. Discussion

The staff and its contractor, Brookhaven National Laboratory, have reviewed the licensee's analysis of the capability of the vent valves to close under the accident conditions.

The 6-inch valves are butterfly valves manufactured by Fisher Controls Company. These valves are described as air open-spring close type, equipped with a Fisher Type 656-60 pneumatic diaphragm actuator.

Fisher's approach to evaluating critical valve parts is to determine 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 several disc angle (usually 10° increments) is compared to the operating pressure condition, in this case, 49.2 psig. from this, maximum disc-opening angle is selected.

Reference 6 presented a tabulation (Table 1) below, which summarized the calculated differential pressure at which the valves operate for angles of opening between 0° and 90°.

Table 1 (for 6-inch valves)

Angles Opening (Degrees)	10	20	30	40	50	60	70	80-90
Differential Pressure (psid)	188.1	185.8	192.1	164.7	138.2	83.3	59.7	35.5
Actuator Torque Required (in-lb)	733.2	738.2	724.5	734.4	733.3	707.3	676.4	644.1

The differential pressure listed in this table was the maximum allowable based on a stress analysis of valve components. The licensee states that since the maximum expected containment pressure is 49.4 psig (Ref. 6), the valve should be capable of closing from 70° open. At this angle, with a differential pressure of 50 psi, the torque required would be 592 in-lb. The licensee goes on to postulate that since it takes 62 seconds after initiation of the accident to reach the maximum of 49.4 psig, and if a valve closing time of 5 seconds is assumed, the actual differential pressure experienced by the valve at this time is less than 35 psig. It is pointed out that Table 1 indicates that at an opening of 80°-90°, the vent valves will close against a differential pressure of 35.5 psig. The valve manufacturer, however, only recommends an opening of 70°.

Based on the conclusions postulated above, and the valve vendor's recommendation, the licensee feels that he is acting conservatively by limiting the valve opening to $\sim$50°.

It was noted by SCECo (Ref. 3), that in-situ testing of equipment modified to limit the valve opening to 50° resulted in the CV-10 valve opening to 53.5° and the CV-116 valve to 47°. It was determined by the licensee that the additional 3.5° opening will not prevent valve CV-10 from closing in the event of a design basis LOCA.

The following tabulation (Table 2) contains information taken from Fisher Controls Company Catalog Number 71 (Ref. 3) regarding spring torque outputs for the Fisher Type 656 diaphragm actuator used with the 6-inch valves.

Table 2 Spring torque outputs (in-lbs) for Type 656 diaphragm actuator

60° maximum Disc rotation	Stem fully retracted	2076
	Stem fully extended	1931
90° maximum Disc rotation	Stem fully retracted	1197
	Stem fully extended	1113

B. Evaluation

The dynamic torque (T_D) predictions used by Fisher stem from coefficients developed by bench tests on model valves representing the design of the in-service valves. Analytical techniques involving scaling are used to determine T_D for the actual valve sizes. The Fisher Control authored I.S.I. paper entitled, "Effect of Fluid Compressibility on Torque in Butterfly Valves," (Ref. 7) gives the basis for Fisher's TD predictions.

Fisher's approach to evaluating critical valve parts is to determine maximum allowable ΔP 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 (usually 10° increments) is compared to the peak containment pressure condition, in this case, 49.4 psig. 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:

- 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.

- 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 a material strength. This strength 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 maximum tensile strength or 2/3 of the minimum yield strength, whichever is less. For shear stresses 0.75 "S" is used.

  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.

- The program output shows the lowest ΔP which is calculated for each angle of opening. The actuator torque required for the lowest ΔP is also listed. This is the information listed in Table 1 above.

The calculations are based on the following assumptions:

1. Peak containment pressure is the ΔP experienced by the valve at all disc angles.

2. Pressure losses due to inlets, piping configuration etc., or other valves in the line are neglected.

3. For valves with asymmetric discs, flow is assumed toward the hub side for predicting dynamic torques.

The staff believes this approach to be a valid and conservative method of determining the expected stresses and the structural valve integrity for the angular open-to-close excursion (50° to 0°).

The above analysis, however, is based on model valve tests with straight inlets which do not account for unsymmetric flow and forces due to elbows or other fittings upstream of the valve. Information available from other valve manufacturers has indicated that for any given valve, using equivalent flow conditions, the dynamic torques developed for a configuration with an elbow upstream of the valve is up to 3 times that developed for a configuration with a straight pipe inlet. Other manufacturers have found that if the valve shaft is in plane with the upstream elbow, the increase in dynamic torque is of the order of 1-1/2 times, while if the valve shaft is 90° out of plane with the elbow, the increase in dynamic torque is of the order of 2 to 3 times.

After reviewing Table 1 and the actuator torque required at a 70° valve opening and 50 psid (592 in-lbs), the staff concurs with the licensee that the valves are capable of withstanding the resulting DBA/LOCA conditions expected. At a 50° opening angle, the valve manufacturer has enough margin to overcome any inaccuracy due to inlet configuration.

The change in the 6-inch (CV-10) valve's limited opening (mechanical stop) from the specified 50° to an actual 53.5° is also within these conservative margins. Additionally, the staff concurs with the licensee that the 3.5° deviation is not sufficient to reduce the margin of conservatism implicit in choosing a 50° maximum disc opening.

Actuator spring torques were furnished by the licensee in Reference 6. These values are shown in Table 2 above. In evaluating the adequacy of the actuator torque margins, the available spring values in Table 2 at 60° (2,076 in-lbs, stem fully retracted, 1,931 in-lbs, stem fully extended) and the torques required were compared. A previously completed purge and vent valve evaluation having this same actuator evidenced that the actuator spring torque is linear relative to the valve's open-to-close excursion.

It is concluded that since the available torque, on average, is greater than 3 times that to be experienced by the valve shaft for an angle opening of 70° and a differential pressure of 50 psid (i.e., 592 in-lbs), the licensee has demonstrated operability and structural integrity from the limited opening angle of 50°.

The licensee has stated that the effect of a seismic event is being addressed as part of "Unresolved Safety Issue A-46 (Seismic Qualification of Equipment in Operating Plants." SCECo is a participating member of the Seismic Qualification Utility Group which is working closely with the NRC staff to resolve this issue.

C. Summary

Based on the above discussion, the staff concludes that the information submitted has satisfactorily demonstrated the ability of the vent valves, as mechanically limited, to close against the buildup of containment pressure in the event of a DBA/LOCA.

IV. RADIOLOGICAL CONSEQUENCES

The staff has reviewed the radiological consequences of a hypothetical LOCA while purging the containment at power, using the 6-inch containment purge system, for San Onofre Unit 1. This evaluation was conducted in accordance with the guidance of Branch Technical Position CSB 6-4, Standard Review Plan Sections 6.2.4 and 15.6.5 and Regulatory Guide 1.3.

This evaluation is based on the release of 119 pounds mass (lbm) of steam prior to the post-LOCA closure of the purge valves at the maximum Technical Specification primary coolant concentration of 60 μCi/gm, dose equivalent I-131. It was assumed that the containment isolation would be achieved before the onset of fuel failure resulting from the accident. The X/Q values were taken from the staff plant data file and are consistent with ground level releases. A list of applicable assumptions is given in Table 3.

The staff reviewed the quantity of air that would be released to the environs prior to valve closure times for the vent line. The staff finds the licensee's calculation of 119 lbm to be acceptable and finds that the valve closure time (including instrument delay times) meet the 15-second total elapsed time limit previously established by the staff for ensuring valve closure before the onset of fuel failure.

The staff estimates that the steam released through the purge line would result in an incremental dose of 1.6 Rem to the thyroid at the Exclusion Area Boundary (EAB) as shown in Table 4. This dose is negligible (less than 1%) when compared to the guideline values of 10 CFR Part 100.

V. NEED FOR PURGING/VENTING DURING OPERATION

In Reference 2, the licensee noted that the vent system is used to maintain the containment atmosphere at or below atmospheric pressure. The unit Technical Specifications require that pressure be below 0.4 psig. As a result of instrument air bleed off, containment pressure would increase if venting did not occur. The licensee expects that several cycles of venting would be required each day to maintain pressure and that this frequent cycling could result in vent valve seat degradation. Furthermore, the cycling would require considerable operator attention and actions.

Since the vent system has normally been in operation, there is no definitive information on the rate of pressure increase that would occur if venting were restricted.

VI. CONCLUSIONS

Based on review of the information provided in the March 27, 1984 licensee letters, the staff concludes the following:

1. The vent valves as mechanically limited are capable of closing against the buildup of containment pressure in the event of a LOCA;

2. The estimated amount of radioactivity released during the time required to close the valves following a LOCA does not cause the total dose to exceed 10 CFR Part 100 guidelines; and

3. The licensee has not at this time provided sufficient justification for unlimited use of the vent system during normal operation.

Therefore, the staff recommends that the licensee either commit to restricting the use of the 6-inch vent system to a low percentage of the total time the plant is at power commensurate with safety-related needs or provide the staff with additional justification, based on continued safe operation of San Onofre 1, for not limiting the use of the 6-inch vent line. If the licensee choses to justify unlimited vent operations at San Onofre 1, the staff recommends that the following areas be addressed in detail by the licensee:

1. A description of the adverse effects on the safety of the plant due to operation during periods of higher than atmospheric pressure inside the containment.

TABLE 3

ASSUMPTIONS USED TO EVALUATE THE CONTAINMENT PURGE CONTRIBUTION TO THE LOCA DOSE

X/Q value (0-2 hour, 283m EAB, ground level release), sec/m^3	9.5×10^{-4}
Purge valve closure time, sec	14
Amount of steam released through the purge valves prior to post-LOCA closure, lbm	119
Maximum technical specification primary coolant limit, dose-equivalent I-131, µCi/gm	60

TABLE 4

RADIOLOGICAL CONSEQUENCES

	EAB, 0-2 HOUR THYROID DOSE
Containment purge contribution	1.6 Rem

NOTES:

1. The X/Q value was taken from the NRC Plant Data File, updated 5/12/83.
2. The whole body doses are not listed because they would be negligible when compared to the guideline values. The LPZ dose would be less than the EAB dose.

2. A quantification of the pressurization rate inside the containment when the 6-inch vent system is closed, and how long it takes to equalize the containment pressure with atmospheric pressure once the purge valves are opened. This can be achieved by cycling the vent system open and closed during normal plant operation.

3. An identification of the sources of air leakages into containment and the costs associated with eliminating these sources.

4. A detailed description of the effects frequent cycling of the purge valves would have on the safety function of these valves and the possible increase in maintenance costs.

Furthermore, since the staff's evaluation of valve operability is dependent on the valve being limited to approximately 50° open, appropriate Technical Specifications to limit the opening angle should be submitted.

VII. ACKNOWLEDGMENT

R. Wright, M. Fields and K. Dempsey contributed to this evaluation.

VIII. REFERENCES

1. Letter from D. Crutchfield (NRC) to R. Dietch (SCE), dated February 17, 1982.

2. Letter from M. O. Medford (SCE) to D. M. Crutchfield (NRC), dated March 27, 1984, Subject: Generic Issue B-24, Containment Purging/Venting During Normal Operations.

3. Letter from M. O. Medford (SCE) to D. M. Crutchfield (NRC) dated March 27, 1984, Subject: Operability of 6" Butterfly Valves used for Containment Venting.

4. Letter from D. Crutchfield (NRC) to K. Baskin (SCE), dated February 16, 1984.

5. Letter from J. G. Haynes (SCE) to D. L. Ziemann (NRC) dated February 29, 1984.

6. Letter from K. Baskin (SCE) to D. L. Ziemann (NRC) dated January 15, 1980.

7. "Effect of Fluid Compressibility on Torque in Butterfly Valves," ISA Annual Conference, ISA Transaction, Vol. 8, No. 4, pg. 18, 1969.

Dated: November 2, 1984