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Department of Nuclear Energy

January 20, 1982

Ms. Mary Haughey
Equipment Qualification Branch
U.S. Nucler Regulatory Commission
Wasington, D.C. 20555

Dear Mary:

Brookhaven National Laboratory (BNL) has reviewed the Fermi 2 purge and vent valve operability demonstration information submitted in letters and presented at the December 2, 1981 audit meeting.

Based on the information available, BNL's Engineering Analysis and Human Factors Group concludes that Detroit Edison can demonstrate that the subject isolation valves are capable of closure under the accident conditions postulated (by the licensee) provided the following is accomplished:

1. All valves are to be oriented so that the flat sides of the discs face the LOCA flow.

2. Applicable valves are to be oriented so that their shafts are "in-plane" with the plane of their associated upstream elbow.

3. A maximum allowable stroke time must be established for each valve for the "inservice test" conditions, i.e., no-load stroke timing. The maximum allowable times established must be low enough to assure that the loads used in the stress analysis presented are not exceeded.

In response to your request concerning time comparisons, Attachment 1 is presented.

Sincerely yours,

Tom

Thomas J. Restivo
Engineering Analysis and
Human Factors Group

TJR:sd
attachment
cc.: R. Bari wo/att.
R. Hall
W. Kato wo/att.
W. Luckas
B. Miller

1.0 REFERENCES

A. Detroit Edison (DE) letter #EF2-55,538 dated November 18, 1981.

B. Meeting - "Purge Valve Audit" at Detroit Edison's Fermi 2 site on December 2, 1981.

C. Wyle Laboratories Report, 55210 - 18.0" Jamesbury Valve Test (shown to staff at audit meeting).

D. Allis Chalmers test report VER-0209 dated December 17, 1979.

E. Enrico Fermi Atomic Power Plant Unit 2, Final Safety Analysis Report, Figure 6.2-11 "Recirculation Line Break - Primary Containment Initial Pressure Transient" (handout at audit meeting).

F. Jamesbury Corporation letter dated November 12, 1981, B.C. Zannini -Jamesbury to J. Green - Detroit Edison (handout at audit meeting).

G. "Aerodynamic Model Tests on Butterfly Valves," by Dr. Ing. C. Keller and Dr. Ing. F. Salzmann, published in ESCHER - Wyss News, Volume IX, No. 1, January March 1936.

H. "Tests on Streamlined Butterfly Valves," by H. Netsch and F. Schulz published in The Engineers Digest, Volume II No. 8, August 1950 (From Maschinenbau und Warmewirtschaft, Volume 4, No. 9, September 1949).

I. "Supportive Data Relating to Torque Coefficient Selection for Jamesbury Wafer-Sphere Valve with 90° Elbow Directly Upstream of Valve" (handout at audit meeting).

J. Allis Chalmers letter, April 30, 1981. R.H. Zeiders (AC) to M. Haughey (NRC) Subject: Butterfly valves for containment isolation, Allis Chalmers Valve Division Tests.

K. Detroit Edison letter EF2-55,980 dated January 4, 1981 (with attachments: a) "Combined Loading Stress Analysis on Shaft for Purge Valves" b) "Seismic Qualification of 6" Purge Valve based on Report JHA-76-34 (PI-2406)."

2.0 EVALUATION

Detroit Edison's/Jamesbury's approach to predicting torque loads for Fermi 2's valves was to establish the inlet pressure to the valve at the various valve positions from 90° (full open) to 0° (full closed). Delay time (LOCA initiate to start of stroke), closure time under load (based on direction of net torque) and containment response (worse-case) are accounted for in their approach.

Based on the information available, BNL's evaluation is as follows:

The drywell pressure response curve in Reference E was given as the design condition for which operability demonstration of all purge and vent isolation valves (drywell and wetwell) is based. During the audit (Reference E) the licensee confirmed that this was the worse-case accident (highest rate of pressure increase) condition. The wetwell response also shown in Reference E is shown to be far less severe relative to valve loads.

Dynamic torque coefficients (C_T) used for the stress analysis of the Jamesbury valves in Fermi 2 stem from an 18.0" Jamesbury valve test program conducted by Wyle Laboratories and reported in Reference C. Pressure and valve closure history data from this test was used in conjunction with data from an actuator - solenoid valve assembly vent test (same type used on test valve at Wyle) to establish C_T values at the various disc angles.

Based on Jamesbury's briefing at the audit meeting and information contained in submittal letters, the following can be summarized:

- The test setup used at Wyle was basically a straight pipe approach flow configuratrion.

- The Wyle test valve was installed and tested only with the discs flat side facing the flow.

- The inlet test pressure during the Wyle tests was higher at all disc angles than the drywell pressure profile given in Reference E.

- The 18.0" test valve at Wyle was of the same design (Wafer Sphere) as the Fermi 2 valves. The aspect ratio of the 18.0", 20.0", and 24.0" were said to be the same.

- The operability case assumed in the load analysis is that one of the two in-series valves is failed in the full open (90°) position.

- Jamesbury assumes a 150% increase in the dynamic torque coefficients developed from Wyle Tests to account for upstream piping elbow affects.

The test setup used at Wyle does not provide data to establish C_T valves based on non-uniform approach flow conditions. Jamesbury has attempted to justify their 150% assumption by comparing their valves to the Allis Chalmers valves which were tested with elbow configurations as reported in Reference D. Jamesbury's comparisons shown in Reference I were on the basis of equivalent aspect ratios (t/D) where the Jamesbury C_T values are shown to be significantly higher than the Allis Chalmers C_T values.

Jamesbury's comparison of C_T' for their design to Allis Chalmer's C_T's on the basis of equivalent aspect ratios alone is inappropriate, particularly based on their approach to determining loads (determining containment pressure vs. disc angle). The comparison does not reflect disc shape differences between the two designs. Information contained in Reference G, Figure 3, indicate that discs having approximately the same aspect ratios but different shapes can have very different coefficients at given disc angles. Some differences were significantly more than were indicated in the Jamesbury - Allis Chalmers comparisons (Reference I).

For those valve installations with an "elbow upstream - shaft oriented out-of-plane configuration," disc closure rotation direction must also be considered when predicting dynamic torques. Allis Chalmer's test program indicated that closure rotation direction would significantly influence torque developed. This aspect was not reported in Reference D, but was made known in Reference J. Jamesbury's analysis has not considered this aspect for the Fermi 2 valves.

Affect on dynamic torque due to flow pattern off of an associated in-series upstream valves had not been addressed by D.E. in their evaluation. Separation distances between each in-series valve pairs was observed (during walk-around inspection) to be small. These distances are much less than the 15D used in the Instrument Society of America's (ISA) Standard S39.4 for a similar configuration.

BNL believes that in the case of the Fermi 2 valves, elbows (where applicable) are in such close proximity to both of the in-series valves, the flow pattern from the elbow should provide the predominant affect on the approach flow pattern as it affects dynamic torque. DE's 150% increase in straight pipe established C_T's to account for the upstream elbow effect is considered conservative for the valve to valve effect.

NOTE: Test results reported in Reference G (Figure 12) indicate that the affect to increase dynamic torque developed in a downstream butterfly valve due to flow distribution off of a modulating upstream butterfly (close proximity) is minor at large angles of upstream valve opening (Figure 12 uses 0° as full open). At smaller upstream valve opening angles, the affect is to significantly reduce the dynamic torque developed in the downstream valve.

Detroit Edison has indicated that they plan to re-orient (where necessary) the subject isolation valves as follows:

a. Flat face of disc to face LOCA flow (This was presented at audit meeting, Reference B).

b. Applicable valves are to be re-oriented so that their shafts are "in-plane" with the plane of their associated upstream elbow (Reference I).

NOTE: Based on information available from submittals and from discussions with some butterfly valve manufacturers, the industry's general belief is that the "in-plane shaft-upstream elbow" configuration is equivalent to the "straight upstream piping" configuration with respect to dynamic torques. No documentation (test or analytical) has been made available by manufacturers or licensee's nor does BNL know of any documentation to support the industry's belief. At this time, BNL can only offer its opinion that the magnitudes of the dynamic torques are likely to be equivalent for the aforementioned configurations.

Based on implementation of these plans, BNL finds that Detroit Edison can demonstrate that the subject valves are capable of closure against the accident condition (LOCA and seismic) postulated.

NOTE: A maximum allowable stroke time must also be established for each valve for the "Inservice Test" conditions i.e., no-load stroke timing. The maximum allowable times must be low enough to assure that the loads used in the stress analysis are not exceeded.

Table 1 summarizes the torque and pressure loads used in the stress analysis as compared to the predicted torque loads at 0° and 90° and maximum containment pressure potential (drywell and wetwell). Predicted torques at 90° are based on 150% of straight pipe determined C_T's and torques at 0° are from seating torque curves presented in Reference A.

As can be seen from Table 1, the torque values used in the stress analysis are significantly higher than the predicted torques at 0° and 90° for the 6.0", 10.0", and 20.0" valves.

The stress analysis torque for the 24.0" valves is shown to be lower than the predicted torque at 90°. The piping installations of the 24.0" valves are considered straight pipe (i.e. uniform approach flow) configured, and as such, the Jamesbury determined straight pipe C_T's would apply. The 3440 ft. lbs. which is the straight pipe predicted torque times 150% should be considered conservative for the 24.0" valves.

The pressure loads used for the stress analysis are also shown to be conservative. Table 1 shows that the pressure loading used in the stress analysis is higher for all valve sizes than the maximum containment pressures predicted. In fact, the pressures used for the 6.0", 10.0" and 20.0" valve are more than twice the maximum pressures predicted.

The licensee has shown that the stress values predicted are within the design allowables specified. Seismic loads have been included in the analysis.

In Reference A, Detroit Edison presented the torque output curves for the various air-operated actuators used on the Fermi 2 valves. Based on these curves, it can be concluded that the operators can provide the torques necessary to close and seat the valves while operating from their 90° (full open) initial position. These same curves indicate that the operator torque ratings are not exceeded.

Detroit Edison also (Reference A) provided information concerning sizing of the motor operator for the 24.0" valve. The information demonstrated that the operators are sized to stroke the valves under the loads postulated at 80% reduced voltage.

Table 1

VALVE ID	SIZE in.	LOCATION DW or WW	STRESS ANALY. TORQUE FT-LBS	TORQUE PREDICTED (LOCA) 0° (FT-LBS)	TORQUE PREDICTED (LOCA) 90° (FT-LBS)	STRESS ANALY. PRESS. (PSIG)	MAXIMUM ACCIDENT PRESSURE DRYWELL (PSIG)	MAXIMUM ACCIDENT PRESSURE WETWELL (PSIG)
V4-2061	6.0	WW	315	160	80	150	--	25
V4-2063	6.0	WW	315	160	80	150	--	25
V4-2060	10.0	DW	730	690	345	150	58	--
VR3-3014	20.0	WW	2300	1700	2060	62	--	25
VR3-3016	20.0	WW	2300	1700	2060	62	--	25
VR3-3013	20.0	WW	2300	1700	2060	62	--	25
VR3-3015	20.0	WW	2300	1700	2060	62	--	25
VR3-3012	24.0	DW	3200	3200	3440	62	58	--
VR3-3023	24.0	DW	3200	3200	3440	62	58	--
VR3-3011	24.0	DW	3200	3200	3440	62	58	--
VR3-3024	24.0	DW	3200	3200	3440	62	58	--
VR3-3019	6.0	WW	260	160	80	62	--	25
VR3-3026	6.0	DW	260	160	80	62	58	--

The maximum potential drywell accident pressure is approximately 58 psig and the wetwell's approximately 25 psig. Both are less than the 68.5 psig ΔP capability based on T_D. Valve closure time from a valve assembly structural integrity standpoint does not appear to be critical for the 6.0" valves.

For 10.0" Valves

a. Use curve D (elbow) where $C_T = 0.0213$
b. $D^3 = 1000\ in^3$
c. $T_D = 730$ ft-lbs.

$$\Delta P = \frac{730}{0.0213 \times 1000} = 34.3 \text{ psi}$$

The 10.0" valve is attached to the drywell. The drywell reaches 34.3 psig in approximately 2.0 sec from LOCA initiate based on the drywell response in Figure 1 (Reference A). This time is approximately three times the 0.65 sec shown by the licensee in Figure 6 (Reference A).

In that the ΔP capability is shown to be less than the maximum drywell potential, it would appear that a limitation is required on the valve closure time allowable during the inservice tests.

For 20.0" Valves

a. Use curve C (elbow) where $C_T = 0.0125$
b. $D^3 = 8000\ in^3$
c. $T_D = 2300$ ft-lbs.

$$\Delta P = \frac{2300}{0.0125 \times 8000} = 23.0 \text{ psig}$$

The 20.0" valves are connected to the wetwell. The maximum potential wetwell pressure is approximately 25 psig (Reference E) which is slightly higher than the ΔP capability of 23 psig which is based on $T_D = 2300$ ft-lbs. Reference E shows that the wetwell would require over 20 seconds to reach 23 psig. This compared to the 1.3 second time shown in Figure 7 (Reference A). Valve closure time from a valve assembly structural standpoint does not appear to be critical for the 20.0" valves.

For 24.0" Valves

a. Use curve A (straight pipe), where $C_T = 0.009$
b. $D^3 = 13824\ in^3$
c. $T_D = 3200$ ft-lbs.

$$\Delta P = \frac{3200}{0.009 \times 13824} = 25.7 \text{ psig}$$

The 24.0" valves are connected to the drywell. Figure 1 (Reference A) shows that the drywell would require approximately one second to reach 25 psig. Figure 8 (CTθ = A) (Reference A) shows valve closure in 1.25 seconds, where the drywell pressure reaches approximately 27 psig. This is higher than the 25.7 psi ΔP capability (based on T_D). As previously mentioned, the C_T value assumed was the maximum value on Curve A (Figure 4) i.e., at 90° (full open). By using a C_T value of 0.005 which is at 75° (less at lower angles) a ΔP capability (based on T_d) of 46.3 psi is calculated. Figure 1 (Reference A) shows that the drywell would require approximately 4 seconds to reach 46 psig. This can be compared to the 1.25 second closure time shown by the licensee for the 24.0" valves.

In that the ΔP capability is shown to be less than the maximum drywell potential, it would appear that a limitation is required on the valve closure time allowable during the inservice tests.