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Docket No. 50-331

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Mr. Lee Liu, Chairman of the Board
and Chief Executive Officer
Iowa Electric Light and Power Company
Post Office Box 351
Cedar Rapids, Iowa 52406

Dear Mr. Liu:

SUBJECT: DEMONSTRATION OF CONTAINMENT PURGE/VENT VALVE OPERABILITY AND ITEM II.E.4.2.6 COMPLIANCE

Re: Duane Arnold Energy Center

We have completed our review of the information submitted concerning operability of the containment purge and vent valves for Duane Arnold Energy Center. Based on our review, we find that the information submitted demonstrated the ability of the 18-inch Fisher control purge/vent valves to close against the buildup of containment pressure in the event of a DBA/LOCA when these valves are limited by mechanical means to an opening angle of 30° on less. This demonstration also satisfies the requirements of the NUREG-0737 Action Item II.E.4.2.6 related to purge/vent valve operability.

Appropriate Technical Specifications which reflect the limitation of opening angle for these valves should be submitted to the NRC within 90 days of the receipt of this letter. Our related Safety Evaluation is enclosed.

Sincerely,

Original signed by:
Domenic B. Vassallo, Chief
Operating Reactors Branch #2
Division of Licensing

Enclosure:
As stated
cc w/enclosure:
See next page

DL:ORB#2	DL:ORB#2	DL:ORB#1	DL:ORB#2
SNorris:jk	MThadani	EReeves	DVassallo
10/1/84	10/1/84	10/1/84	10/1/84

Mr. Lee Liu
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Duane Arnold Energy Center

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UNITED STATES
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WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

DEMONSTRATION OF CONTAINMENT PURGE AND VENT VALVE OPERABILITY

DUANE ARNOLD ENERGY CENTER

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

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

Valve No.	Size (Inches)	Use	Location
CV-4300	18	Exhaust	Outside containment
CV-4301	18	Exhaust	Outside containment
CV-4302	18	Exhaust	Outside containment
CV-4303	18	Exhaust	Outside containment
CV-4306	18	Supply	Outside containment
CV-4307	18	Supply	Outside containment
CV-4308	18	Supply	Outside containment

This information was derived from a sketch titled "Containment Purge Isolation System," submitted by the licensee by letter of February 15, 1980.

The valves are butterfly valves, manufactured by Fisher Controls, Type 9220, equipped with air to open/spring to close Bettis actuators, Model 722C-SR-60.

3.0 Demonstration of Operability

The Iowa Electric Light and Power Company (IELP) has submitted information concerning the purge and vent valves for Duane Arnold Energy Center (DAEC) in the following documents. Sections 3.1 through 3.6 are excepts from these submittals.

A. January 3, 1979, letter, L. Liu of IELP to T. Ippolito, NRC, ORB No. 3.
B. March 3, 1979, letter, L. Liu of IELP to T. Ippolito, NRC ORB No. 3.
C. March 6, 1979, letter, E. Hammond of IELP to J. Keppler, NRC, I&E.
D. September 20, 1979, letter, E. Hammon of IELP to J. Keppler, NRC, I&E.
E. September 27, 1979, letter, E. Hammond of IELP to J. Keppler, NRC, I&E.
F. December 19, 1979, letter, L. Root of IELP to T. Ippolito, NRC, ORB No. 3.
G. February 15, 1980, letter, L. Root of IELP to T. Ippolito, NRC, ORB No. 3.
H. March 15, 1980, letter, L. Root of IELP to H. Denton, NRC, NRR.
I. June 10, 1983, letter, R.W. McGaughy of IELP to H. Denton, NRC.
J. February 10, 1984, letter, R.W. McGaughy of IELP to H. Denton, NRC.

3.1. The as-installed closure time for all these valves is 1-4 seconds under no-flow conditions (from 30° open as in the DAEC application). This represents the shortest and longest closing times observed during post surveillance testing of all 18-inch butterfly valves. Because flow aids closure, the closure time under flow conditions will be at least this fast even at higher pressures in the drywell following a postulated LOCA. Only friction and seating loads must be overcome. These loads (in the order of 2,000-3,000 in-lbs) are well within the capabilities of the spring-return torque from the actuator, disregarding the assistance from the flow-closed effect. Because of the scotch-yoke mechanism the closure rate will not be perfectly linear, however, closure would be achieved in 1-4 seconds or less at a differential pressure of at least 56 psi during flow conditions. Note: containment design pressure is 56 psig, the maximum pressure resulting from a postulated design basis LOCA is 54 psig (which occurs more than 100 seconds after accident initiation).

3.2 In the closing direction, the spring action must be sufficient to overcome the friction and seating loads only, because flow aids closure. These loads (3,280 in-lb at 0°, 2,016 in-lb at 30°), are well within the spring-return torque available (4,750 in-lb at 0°, about 3,800 in/lb at 30° open). Therefore, the actuator is adequate for achieving closure from the 30° open position against the Design Basis LOCA differential pressure.

3.3 The preferred orientation for Type 9220 butterfly valves is to have the T-ring retaining ring on the outlet side of the valve. However, closure can be achieved regardless of flow direction. These valves are equipped with CF8M offset cast discs; therefore, flow direction will have no significant effect on valve capacity. However, more torque will be required for flow into the hub side of the disc. This condition has been assumed as the worst case and used throughout the analysis. When pinned at 30° maximum opening angle as in the DAEC application, these valves will close, regardless of flow direction, against at least 56 psi differential pressure.

3.4 The submittals states that essentially uniform flow is achieved within 4-5 pipe diameters downstream from a pipeline discontinuity. If pipeline discontinuities are closer than 4-5 pipe diameters on the upstream side, the effect on capacity and torque is related to the disc shaft orientation with respect to the non-uniform flow pattern.

Six of the seven valves have no turns or bends within approximately 4 pipe diameters on the upstream side of the valves, consequently there is little effect on the flow pattern at the valve. One valve, CV-4301, is located approximately 2-1/2 pipe diameters downstream of a piping bend. The effects of this bend on valve closure is described in detail in Section 3.5.

Four of the seven valves have no branch lines within 4 to 5 pipe diameters of the valves. Valves CV-4307 and CV-4308 have 6-inch branch connections approximately 2 pipe diameters upstream of the valves. These connections will not be in use while purging through CV-4307 or CV-4308 and will have a negligible effect on flow. Valve CV-4306 is located downstream of a piping branch and is discussed in detail in Section 3.5

3.5 Orientation of the valve shaft at 90° to the plane of the piping branch would result in maximum unequal impingement on the valve disc wings for valves located within 4 to 5 pipe diameters of the branch. Orientation of the valve shaft in the plane (0°) of the piping would result in no net effect on the valve disc from the non-uniformities of flow caused by the branch line.

As indicated in Section 3.4, in two valve cases (CV-4301 and CV-4306) the effects on non-uniformities in flow (caused by a nearby bend or branch line) are minimized by the valve shaft orientation relative to the plane of the bend or branch line. These two valve cases are described below.

Valve CV-4301 is located near a pipe bend and is oriented with the valve shaft in the plane of the piping bend so that potentially non-uniform flow is split and equal on either side of the valve shaft. This configuration does not affect the torque thus allowing normal valve closure. There are no close discontinuities for the remaining valves, therefore the orientation of the disc and shaft is immaterial, because the flow will be essentially symmetrical.

Valve CV-4306 is located approximately one pipe diameter from a branch line (from the torus) which would affect the uniformity of flow at the valve. The valve shaft for valve CV-4306 is oriented 16-1/2° to the plane of the piping branch. To analyze the effects of non-uniformities in flow (caused by this branch line) on closure operability of the valve, the three potential purging system lineups are considered.

For the case of system lineup to purge the drywell only or to purge both the drywell and torus simultaneously, the drywell purge isolation valves are open. The effect of non-uniform flow from the drywell (due to the LOCA transient) caused by the branch line opening is minimal because of the small angle (only 16-1/2°) between the valve shaft orientation and the plane of the piping branch.

For the case of system line up to purge the torus, only the drywell purge isolation valve is closed and the effect of non-uniformities in flow from the torus (due to the LOCA transient) are caused by the flow making the turn from the branch line. For such a case, the effect of the non-uniformities in flow are minimized by both the small angle between the valve shaft and the plane of the piping branch and because the pressure transient in the torus is both lower in peak value and delayed in time compared to the drywell transient and the maximum pressure across the valve would be 16 psi at 5 seconds post LOCA (using data from UFSAR Figure 6.2-45).

Based on these considerations, the operability of the DAEC purge and vent valves is not degraded by purge and vent piping effects (turns, branches, etc.) upstream and downstream of the valve installations.

3.6 A seismic analysis dated March 21, 1972 was performed for the subject valves by Fisher Controls Company. Based on the Fisher Controls calculations it has been demonstrated that the primary steady state stresses, when combined with the inertial loading resulting from the response to a ground acceleration of 4.0 g acting in the vertical and 3.0 g acting in the horizontal planes simultaneously, produce combined stresses which are well within the yield stresses of the construction materials, both in tension and in shear.

Also, Fisher calculations have verified that the extended structures of each valve assembly have a natural frequency of vibration greater than 20 cycles per second.

4.0 Evaluation

4.1 From the submittals of other licensees which use valves manufactured by Fisher Controls, the staff is familiar with the process by which this valve manufacturer analyzes his valves. 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," (Reference D) gives the basis for Fisher's T_D 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 (10° increments) is compared to the operating pressure condition, in this case, 56 psi across the valve. 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 code allowable stress. 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 maximum tensile strength of 2/3 of the minimum yield strength, whichever is less. For shear stresses, 0.75 "S" is used as the allowable.

- 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.

- 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.

Inherent in the calculations are the following conservative assumptions:

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

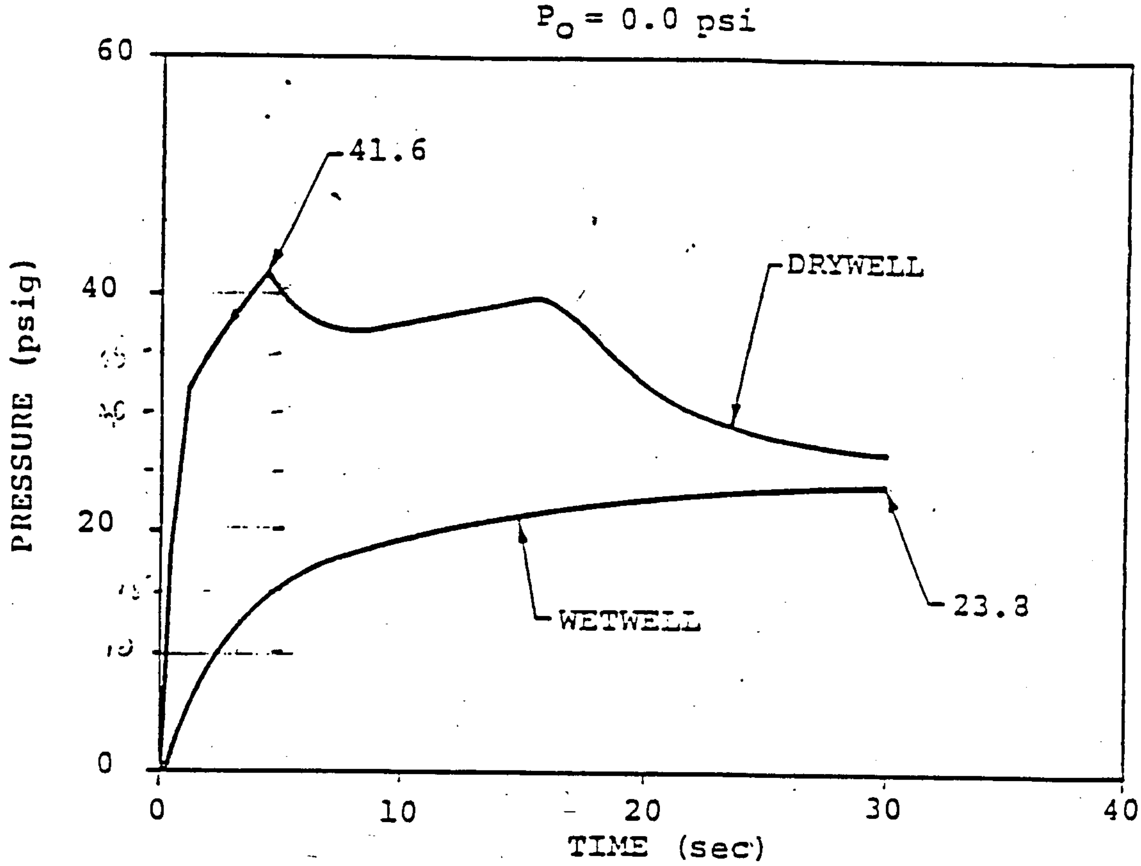
2) Pressure losses due to inlets, piping configuration etc., or other valves in the line are neglected.

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

The accident conditions used by Fisher conservatively assumes that the total containment pressure is seen as the ΔP across each of the isolation valves from their full open position of 30° to the full closed position. This differential pressure is 56 psi.

Additionally Reference J states that a recent analysis showed that the peak containment pressure resulting from a postulated LOCA will be less than 42 psi in the drywell and a wetwell pressure of 20 psi 10 seconds after initiation of the accident. A copy of the DBA/LOCA containment pressure response curve from the DAEC Plant Unique Analysis Report (PUAR) for the Mark I loads program was provided and is presented below.

4.2 The licensee states, to which the staff agrees based on previous submittals, that in the closing direction, the spring-action must be sufficient to overcome the friction and seating loads only, because flow aids closure. The table below summarizes these loads.



EVENT DESCRIPTION	PRESSURE DESIGNATION	TIME (sec)		PRESSURE (psig)			
		t_{min}	t_{max}	P_{min}	ΔP_{min}	P_{max}	ΔP_{max}
INSTANT OF BREAK TO ONSET OF POOL SWELL	P_1	0.0	1.5	1.0	1.0	33.0	26.0
TERMINATION OF POOL SWELL TO ONSET OF CO	P_2	1.5	5.0	33.0	24.8	41.6	27.0
ONSET OF CO TO ONSET OF CHUGGING	P_3	5.0	35.0	27.0	3.0	40.0	24.3
ONSET OF CHUGGING TO RPV DEPRESSURIZATION	P_4	35.0	65.0	22.0	3.0	27.0	3.0

1. DBA VENT SYSTEM INTERNAL PRESSURE LOADS ARE INCLUDED IN VENT SYSTEM PRESSURIZATION AND THRUST LOADS SHOWN IN TABLE 3-2.2-3.

Figure 3-2.2-3

VENT SYSTEM INTERNAL PRESSURES FOR DBA EVENT

Degree	Friction/Seating Loads (in-lbs)	Spring-Return Torque (in-lbs)
0	3,280	4,750
30	3,016	3,800

The Fisher analysis reports that at an open angle of 30° and a 56 psid, the actuator torque required 4,287.2 in-lbs. Therefore, accounting for the conservatism mentioned in Section 4.1, that at 30° flow tends to close the valve and the methodology applied by the staff, discussed in Section 4.3, the staff finds that for valves located 4 pipe diameters downstream of an elbow tee, etc. the licensee has demonstrated operability and the structural integrity of the internal valve parts.

Valves CV-4301 located 2-1/2 pipe diameters downstream from a piping bend, CV-4307 and CV-4308 located 2 pipe diameters downstream of a pipe connection, and CV-4306 located one pipe diameter downstream of an branch line are reviewed in further detail in Section 4.3.

4.3 Valves CV-4307 and CV-4308 have 6-inch branch connections approximately 2 pipe diameters downstream. The licensee reports that these connections are not in use during the purging mode of operation resulting in negligible effects on flow, to which the staff agrees. Therefore, the upstream configuration for these valves is considered to be a straight run of pipe to which operability and structural integrity have been demonstrated.

Valve CV-4306 is located 1 pipe diameter from a branch line leading from the torus that would affect flow and is 16-1/2 degrees out of plane. In review, the submittal, the staff took exception to the reasoning the licensee used in demonstrating operability (Section 3.4). However, the staff has applied the following methodology in demonstrating operability.

Fisher's model valve bench test programs used to develop dynamic torque coefficients (C_T) were configured with straight pipe inlet test configurations. Testing did not include inlet configurations involving elbows and therefore the effects on C_T cannot be quantified for those Duane Arnold valves affected by flow off of an upstream elbow.

Information available from other valve manufacturers indicated that for a given valve design at the same conditions, the ratio of C_T (elbow-shaft in plane) to C_T (straight pipe) is greater than one and the ratio of C_T (elbow-shaft out plane) to C_T (straight pipe) is greater than two in some instances. Use of straight pipe developed C_Ts for in service valves with an upstream elbow configuration would result in dynamic torque predictions that are not conservative given the information available.

Based on limited elbow testing information available, the staff believes that where bench tests did not include elbows in the piping configurations, a factor of 1.5 times, the C_T (straight pipe) for an elbow-shaft in plane valve installation configuration and a factor of 3 times the C_T (straight pipe) for an elbow-shaft out of plane valve installation configuration would yield conservative values of T_D.

Although Fisher does not have data to quantify the effect on C_T (straight pipe) values due to elbows, it can be demonstrated that the internal parts of the valves have sufficient design margins to withstand the loads developed during closure under DBA/LOCA conditions. A simplistic and conservative approach to demonstrating design margin is to make the assumption that the installation configuration of the valves is the worst case relative to T_D prediction, i.e., elbow-shaft out of plane. Increasing the C_Ts (straight pipe) by a factor of 3 increases T_D by a factor of 3 which effectively reduces the maximum allowable ΔPs to one-third that calculated by Fisher. Fisher assumed a constant peak containment pressure of 56 psi at 30° disc angle. One-third of 56 psid is 18.7 psid. Comparing this maximum allowable ΔP of 18.7 to the 20 psi design condition pressure in the wetwell discussed in Section 4.1 of this report results in a design margin of .94 to 1.

Since the valve is 16-1/2° out of plane, the staff concludes that it is too stringent to apply the out of plane factor. Applying a 1.5 and 2 factor results in maximum allowable ΔP of 37 psi and 28 psi, respectively. Comparing this to a 20 psi design condition in the wetwell results in a design margin of 1.85 and 1.4, respectively.

Therefore, structural integrity of the internal valve parts of CV-4306 is demonstrated. The reason for the staff's finding is that the maximum allowable ΔP at disc angles of 30° and lower is given to be 56 psid. Comparing this 56 psid allowable to the 20 psid design condition discussed in Section 4.1 of this report results in a design margin of 2.8 to 1.

In reviewing CV-4301, the same theory was applied except the valve is in plane thus a 1.5 factor was applied. Thus 56 psi divided by 1.5 is 37 psi. Comparing this maximum allowable ΔP of 37 psi to the 27 psi design condition in the drywell (see Section 4.1) results in a design margin of 1.37 to 1.

The structural integrity of the internal valve parts of CV-4306 is demonstrated by the same means. The analysis assumed a ΔP of 56 psi. Comparing this to a pressure of 27 psid design condition discussed in Section 4.1, results in a design margin of 2.07 to 1.

4.4 The licensee reports that a seismic analysis dated March 21, 1982 was performed by Fisher Controls and they concluded that the valves are capable of performing their intended function during and following a seismic DBE.

5.0 Summary

We have completed our review of the information submitted to date concerning the operability of the purge and vent valves for Duane Arnold. We find that the information submitted demonstrates the ability of the purge and vent valves to close against the buildup of containment pressure in the event of a DBA/LOCA. Sections 4.1, 4,2, 4.3, and 4.4 are basis for this conclusion.