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SUBJECT: Forwards addl info re qualification of isolation capability of 12-inch containment vacuum/overpressure relief valves.

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July 5, 1988

PG&E Letter No. DCL-88-176

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

PG&E

Re: Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Additional Information Regarding Qualification of Isolation Capability of 12-Inch Containment Vacuum/Overpressure Relief Valves and License Amendment Request (LAR) 86-11

Gentlemen:

PG&E letter DCL-86-233, dated August 8, 1986, submitted "Qualification of Isolation Capability of 12-Inch Containment Vacuum/Overpressure Relief Valves FCV-662, FCV-663, and FCV-664 After a Loss-of-Coolant Accident" to fulfill a commitment in SSER 31. The letter commited to submittal of a license amendment request by PG&E to revise the Technical Specifications (TS) to require a maximum 5 second closure time for the subject valves. PG&E Letter DCL-86-319, dated October 29, 1986, submitted LAR 86-11 to require 5 second closure times for FCV-662, FCV-663, and FCV-664.

Subsequent discussions with the NRC Project Manager indicate that additional information should be submitted regarding the assumptions used in the evaluation submitted in letter DCL-86-233. The enclosure provides the additional information requested and the attachments supercede the evaluation submitted in DCL-86-233 and DCL-86-249. However, the Technical Specification portion of PG&E's LAR 86-11 remains unchanged.

Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it in the enclosed addressed envelope.

Sincerely,

J. D. Shiffer

Enclosure

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2158S/0061K/DY/809

ENCLOSURE

Additional Information
Regarding Revision of Technical Specification (TS) Table 3.6-1
Containment Isolation Valves

Technical Specifications (TS) 3.6.1.7, "Containment Ventilation System," states that containment purge system operation with any two of three lines (one purge supply, one purge exhaust line, and the vacuum/pressure relief line) open is permitted.

PG&E's evaluation, "Qualification of Isolation Capability of 12-Inch Containment Vacuum/Overpressure Relief Valves FCV-662, FCV-663, and FCV-664 After a Loss Of Coolant Accident," submitted in DCL-86-233 assumed that the containment vacuum/overpressure relief valves would not be opened concurrently with the containment purge supply line or the containment purge exhaust line. However, this assumption is not consistent with operation during Modes 1-4 with any two of the three lines open as allowed by TS 3.6.1.7. Accordingly, a revised evaluation was performed and is provided as Attachments 1 and 2 to this enclosure. Revisions to the previous evaluation are indicated with revision bars in the right hand column.

The revised evaluation scope consisted of (1) a review of the system design, maintenance, and surveillance test program, (2) dynamic analysis, and (3) radiological consequences assessment. The system design, maintenance, and surveillance test program portion of the evaluation is not influenced by the assumptions on the number of containment ventilation lines that are open at any one time. The purpose of the dynamic analysis is to determine valve closure time and to assess the stress levels in critical parts of the valve. The dynamic analysis and stress calculations were performed for a single purge pathway and the maximum pressure drop across a single valve. This is a conservative approach and envelopes the conditions allowed by TS 3.6.1.7 (i.e., two pathways).

A revision to the original offsite dose calculations, for the containment purge valves open, was prepared when the 48-inch containment purge supply line, the 48-inch containment purge exhaust line, and the 12-inch vacuum/pressure relief line all open coincident with a LOCA. This is a conservative calculation because TS 3.6.1.7 allows only two of these three lines to be open at one time. The flow in the purge and vacuum/overpressure relief lines were conservatively calculated. The high initial flow rate was assumed over the entire period until valve closure; that is, no credit was taken for reduced flow during valve closure. The 12-inch valve was assumed to be blocked to open no more than 50° with closure in 5 seconds. The offsite exposures which result from the 48-inch and 12-inch containment purge/relief lines being open following a LOCA are within the allowable limits of 10 CFR 100. The offsite LOCA exposures due to open containment purge valves are less than one percent of those resulting from containment leakage as given in the Diablo Canyon Units 1 and 2 FSAR Update, Table 15.5-23.

ATTACHMENT 1

DIABLO CANYON POWER PLANT

UNITS 1 AND 2

QUALIFICATION OF ISOLATION CAPABILITY OF 12-INCH CONTAINMENT VACUUM/OVERPRESSURE RELIEF VALVES FCV-662, FCV-663, AND FCV-664 AFTER A LOSS-OF-COOLANT ACCIDENT

1. INTRODUCTION

1.1 General

PG&E has elected to maintain the DCPP Units 1 and 2 12-inch containment vacuum/overpressure relief valves FCV-662, 663, and 664 (relief valves) blocked to prevent opening beyond 50° (90° is full open) for the life of the plant. NRC Standard Review Plan 6.2.4 requires an evaluation of the containment purging system if an open path is provided from the containment to the environs during normal plant operation. This report presents the evaluation and qualification of the isolation capability of the relief valves after loss-of-coolant accidents (LOCAs). The evaluation of the relief valves used similar methodology to that previously used by PG&E for the 48-inch purge supply and vent valves. The previous evaluation was accepted by the NRC Staff in SSER 9 (June 1980), and the NRC Staff concluded that the evaluation and methodology comply with the criteria contained in NRC Branch Technical Position (BTP) CSB 6-4, "Containment Purging During Normal Plant Operations."

1.2 Valve Specifications

The relief valve specifications are:

12-inch containment vacuum/overpressure relief valve
Item No. 31 FCV-662, FCV-663, and FCV-644
Valve manufacturer: Fisher Controls
Type: Butterfly
Model: 9120
Actuator: Bettis 722B-SR (Figure 1 of the Attachment shows the valve/actuator arrangement)

1.3 Operating Conditions

The operating conditions for the evaluation are as follows:

- The subject relief valves are normally closed and have been permanently blocked to prevent opening beyond 50° (90° is fully open). The evaluation of these valves below the 50° position provides assurance of safe operation during postulated LOCA events.

- The vacuum/overpressure relief line can be used when one of the purge/vent lines are used.

2. EVALUATION

The evaluation scope covers:

- System design, maintenance, and surveillance test program
- Dynamic analysis
- Radiological consequence assessment

2.1 System Design, Maintenance, and Surveillance Test Program

The containment vacuum/overpressure relief line is part of the containment isolation system, and as such, meets all of the standards appropriate to engineered safety features.

The redundant inside and outside containment vacuum/overpressure relief valves are on separate safety trains, and each valve has a spring return actuator closing on loss of air. These valves also close on loss of electrical power. Therefore, no energy sources are required to close these valves.

The subject valves are manually controlled, pneumatically actuated, and are installed in the orientation of pressure relief as the normal flow direction.

The maintenance and surveillance tests performed for these valves are consistent with those for other engineered safety features and include leak test, position switch test, close-time test, and isolation signal test.

2.2 Dynamic Analysis

The dynamic analysis method used is similar to that used and previously accepted by the NRC Staff (SSER 9) for the DCPP 48-inch purge and vent valves. A brief description of the general approach, the method, the results, and the criteria used follows. Due to the insignificant mass of the disc, stresses in the disc shaft and key due to seismic events are very small and, therefore, not considered. The Attachment provides a discussion of the equations used in the analysis, which are similar to those previously used and submitted to the NRC Staff for the 48-inch purge/vent valves.

The purpose of dynamic analysis is (1) to determine the valve closing time after receiving the isolation signal, and (2) to establish the stress levels in the critical structural parts of the valve, namely the disc shaft and the key.

The dynamic analysis method is summarized by the following steps:

- The valve disc dynamic equation of motion was defined in terms of:
  - Disc mass moment of inertia (I)
  - Disc aerodynamic characteristics (aerodynamic torque Td)

- Cylinder spring effect (spring torque Ts)
- Actuation effect (actuator torque Ta)

o The spring force of the actuator cylinder (which includes the nonlinear and frictional effects) as a function of valve disc opening angle was obtained from an in-situ test. The test results are shown in Figure 2 of the Attachment in the form of a hysteresis curve. This force was used to calculate the spring torque, Ts, in the first step.

o The disc dynamic equation of motion was solved numerically in small time increments under the driving force of LOCA containment pressure transients to obtain the closure time and the disc angular velocity at closing.

o The disc shaft and key stresses at valve closing were conservatively calculated by assuming that all of the impact kinetic energy is transferred as strain energy in the angular deflection of the shaft.

The dynamic equation of motion was derived by coupling the flow and disc dynamics to the aerodynamic torque expression provided by the valve manufacturer, Fisher Controls.

Three cases of LOCA containment pressure transients as shown in Figure 3 of the Attachment were analyzed:

Case 1 - Double-ended cold leg rupture
Case 2 - Double-ended pump suction rupture
Case 3 - 3 ft^2 pump suction rupture

The results of the evaluation for the three LOCA cases are summarized below and show that in all cases the valve closure times and stresses are much less than allowable.

COMPARISON OF RESULTS FOR LOCA CASES

(Values Shown for 45° and 50° Open Positions)

Items	LOCA Case 1	LOCA Case 2	LOCA Case 3	Allowable Values
*Valve Closure Time (sec.)	3.42/3.51	3.48/3.59	3.88/4.01	5.00
Stress in Key (psi)	5,468/5,708	5,522/5,732	5,533/5,706	39,500
Stress in Shaft (psi)	10,550/11,010	10,650/11,060	10,670/11,010	67,000

*NOTE: 1. The Technical Specifications require these valves be blocked to limit opening to 50 degrees. The valve blocks are nominally set to 45 degrees.

2. The maximum valve closure time measured during the onsite test under normal plant operation (including the 0.5 second signal delay) is 3.25 sec.

3. With the valve closure time of 5 seconds, the dynamic stresses are not expected to increase by more than 20 percent. In that case the stresses would still be well below the allowable values.

2.3 Radiological Consequence Assessment

The 12-inch vacuum/overpressure relief valves are significantly smaller than the 48-inch purge/vent valves, and they are permanently blocked to a maximum 50° valve opening. In SSER 9, the NRC Staff concluded that radiological consequences associated with use of the 48-inch purge/vent valves are within the guidelines of 10 CFR 100. The increases in offsite exposures which result from the 48-inch and 12-inch containment purge/relief lines being open following a LOCA are within the applicable limits of 10 CFR 100. The offsite LOCA exposures from the containment purge valves are less than one percent of the off site LOCA exposures resulting from containment leakage as given in the Diablo Canyon Units 1 and 2 FSAR Update, Table 15.5-23.

3. SUMMARY OF RESULTS

Based on the evaluation described herein, PG&E concludes that the 12-inch containment vacuum/overpressure relief valve isolation capability is demonstrated, in that:

- o The system design meets the standards of engineered safety features; maintenance and surveillance test programs currently performed are adequate and will ensure operability of the relief valves.

- The valves will be closed within 5 seconds (including a 0.5 second signal delay time) after a LOCA.
- The maximum stress in the disc shaft and key are well within allowable stress limits.
- Radiological consequences following a LOCA are within 10 CFR 100 guideline values.
- The relief valves conform to the criteria specified in Branch Technical Position CSB 6-4 and Standard Review Plan 6.2.4.

ATTACHMENT 2

DESCRIPTION OF ANALYSIS OF
12-INCH VACUUM/OVERPRESSURE RELIEF VALVES

Dynamic Characteristics of Valves and Actuators

The actuators are a scotch-yoke arrangement (Figure 1) which uses a push-pull action of the two pneumatic actuators to open a valve. Pneumatic pressure in the actuator cylinders maintains a valve in the open position. A signal to close a valve opens a solenoid valve which relieves the pressure in the actuators and allows a spring in one of the actuators to close the valve.

Air flowing through the valve creates an aerodynamic lift effect which acts in a direction to close the valve. In all normal operating modes, there is a very small differential pressure across the valve; consequently, the aerodynamic torque is insignificant and is counterbalanced by the pneumatic actuators.

Time-History Analysis of Valve Parameters

A FORTRAN computer program, VALVE, has been developed to calculate valve and actuator parameters as a function of time for LOCAs described in the Diablo Canyon FSAR (Figure 3). This Attachment briefly describes the analytical model and calculation methods of the computer program.

Input Data

1. Containment pressure (psig) as a function of time (seconds) after a LOCA is stored in arrays CP and TAL, respectively.

2. The left side of the actuator/valve hysteresis curve (measured pressure and position data for closing of valves) is entered in the arrays LSHCA (abscissa) and LSHCO (ordinate).

3. The valve pressure/flow characteristic (CV) and valve position (degrees open) are stored in the arrays CV and CVVP, respectively.

4. The containment temperature (degrees F) and time (seconds) after the start of a LOCA are entered in the arrays CT and CTT, respectively.

5. Water vapor saturation volume (cubic feet/pound) and pressure (psi) are stored in the arrays SV and PSV, respectively.

6. The aerodynamic torque coefficients (inch pounds/psi) and valve position (degrees) are stored in arrays ATCØ and ATCA, respectively.

Calculation of Parameters

Predicted valve position (PVP): The valve position can be accurately predicted by using the calculated valve position (VP), angular velocity (AV), and angular acceleration (AA), which were calculated in the previous calculation interval. (The time increment (ΔT) = constant = 0.005 seconds.)

$$PVP_{n+1} = VP_n + AV_n \cdot \Delta T + \frac{AA_n \cdot (\Delta T)^2}{2}$$

The predicted valve position is used to determine the actuator parameters (actuator position, pressure force, spring force, net torque, and actuator air volumes).

After the valve position is calculated (based upon calculated torques, acceleration, velocity, and valve position during previous interval), the difference between valve position and predicted valve position is calculated. For accurate results, this difference is kept very small (0.02°).

The geometric model is shown in Figure 1. The valve actuator is adjusted so that when the actuator arm is at a 45° angle (THETA), the valve position is fully open (i.e., 90°).

$$\begin{aligned} THETA &= PVP - 45^\circ \\ AP &= 2.5 + 2.5 \tan(THETA) \\ AV\emptyset L &= (77)\cdot(AP) \end{aligned}$$

Actuator Pressure and Standard Air Volume

The model uses an instrumentation time delay of 0.5 seconds between the time of the containment isolation pressure setpoint (3 psig) and the opening of the solenoid valves to relieve the actuator pressure. When the solenoid valve is open, the actuator air loss rate is based upon the equation:

$$Q = 963\ CV\sqrt{\frac{\Delta P}{T}}$$

Q: Flowrate SCFH
ΔP: Differential Pressure, psig
T: Degrees Rankine
CV = 0.35

If the solenoid valve has not opened, the actuator pressure (P) is predicted from the air volume at the current position and the air volume and pressure of the previous calculation interval.

Aerodynamic Torque

The aerodynamic torque is calculated by the formula

$$T_{aero} = (A + B) \cdot \Delta P + C$$

where A and C are constants. A = 28.8, C = 1200 inch pounds/psi for these valves, and B is a function of valve type and valve position. The coefficient

B is named ATCØT in the program and is read from the arrays ATCA and ATCØ for the calculated valve position in each time interval.

Hysteresis Curve

The measured valve position versus actuator pressure data is presented in Figure 2. In each calculation interval, the net torque on the disc, the net torque on the disc during the previous calculation interval, and the previous position on the hysteresis curve are used to determine the current position on the hysteresis curve.

Acceleration, Velocity, and Position of Valve Disc

The angular acceleration (AA), angular velocity (AV), and valve position (VP) are calculated at each time step ΔT as follows:

$$AA_{n+1} = \frac{\text{Net Torque}}{\text{Mass Moment of Inertia}}$$

$$AV_{N+1} = AV_n + AA_{n+1} \cdot \Delta T$$

$$VP_{n+1} = VP_n + AV_{n+1} \cdot \Delta T + AA_{n+1} \cdot \frac{(\Delta T)^2}{2}$$

Capability of Valves to Withstand the Effects of Slamming Shut

The angular velocity of the valves at the time of closing was calculated in degrees per second. The kinetic energy of the valve would be partially absorbed in the seating of the valve. The remaining kinetic energy would be stored in torsional strain energy in the twisting of the shaft. The valve disc energy would be absorbed in the hysteresis of the actuator and the energy required to seat the valve.

The calculations given below verify that the shaft and shaft-keys have sufficient strength to withstand the closing forces. The method that is used in the calculations is to assume that all of the kinetic energy of the disc is stored as strain energy in the angular deflection of the shaft, calculate the angular deflection, determine the torque associated with it, and determine the resulting stress on the shaft keys.

Kinetic Energy = Strain Energy:

$$1/2\ IW^2_{MAX} = 1/2\ JG \frac{\theta^2_{MAX}}{L}$$

$$\theta_{MAX} = w_{MAX} \sqrt{IL/JG}$$

Maximum Shaft Torque:

$$T = JG\theta_{Max}/L$$

Force on Shaft Keys:

$$F = 1/2 \ \frac{I}{r}$$

Shear Stress:

$$Ss = F/A$$

Bearing Stress:

(Formula from <u>Formulas for Stress and Strain</u>, Roark, 6th Edition, page 334.)

$$S_b = 2\ Ft/b^2 l$$

Maximum Shear Stress:

$$(Ss)_{MAX} = \sqrt{\left(\frac{S_b}{2}\right)^2 + Ss^2}$$

where

I:	mass moment of inertia
J:	moment of inertia
G:	shear modulus
W_{MAX}:	angular velocity at impact
L:	disc shaft length
l:	length of shaft key
b:	width of the shaft key
t:	thickness of shaft key
θ, θ_{MAX}:	angular shaft rotation

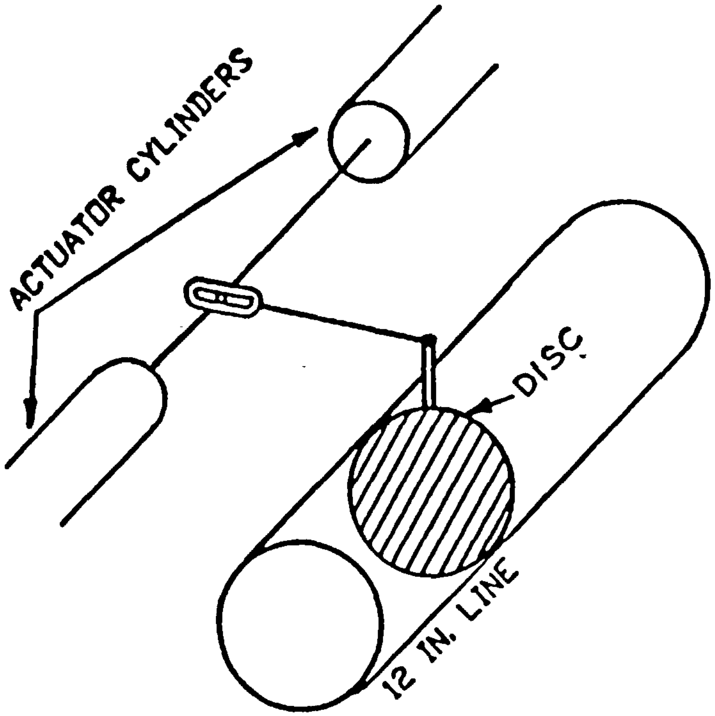

FIG. 1A 12 IN. CONTAINMENT VACUUM/ OVERPRESSURE RELIEF VALVE SCHEMATIC

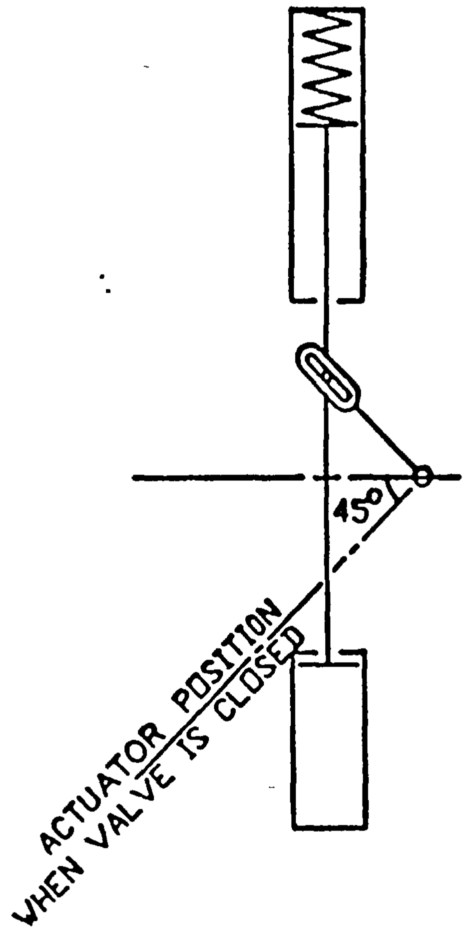

FIG. 1B 12 IN. CONTAINMENT VACUUM/ OVERPRESSURE RELIEF VALVE DISK DRIVING MECHANISM

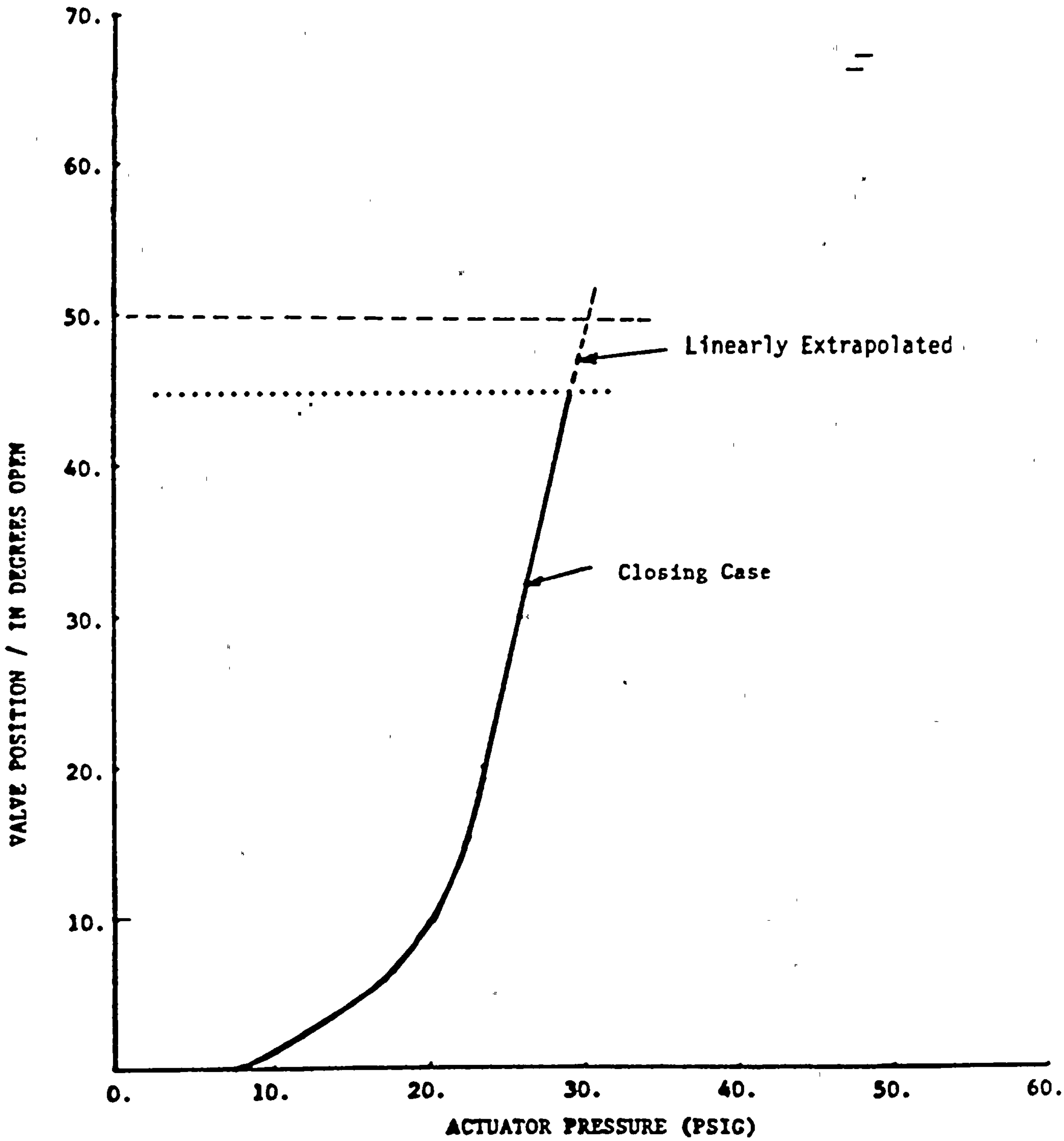

Figure 2 12 inch Containment Vacuum/Overpressure Relief Valve Closing Hysteresis Curve

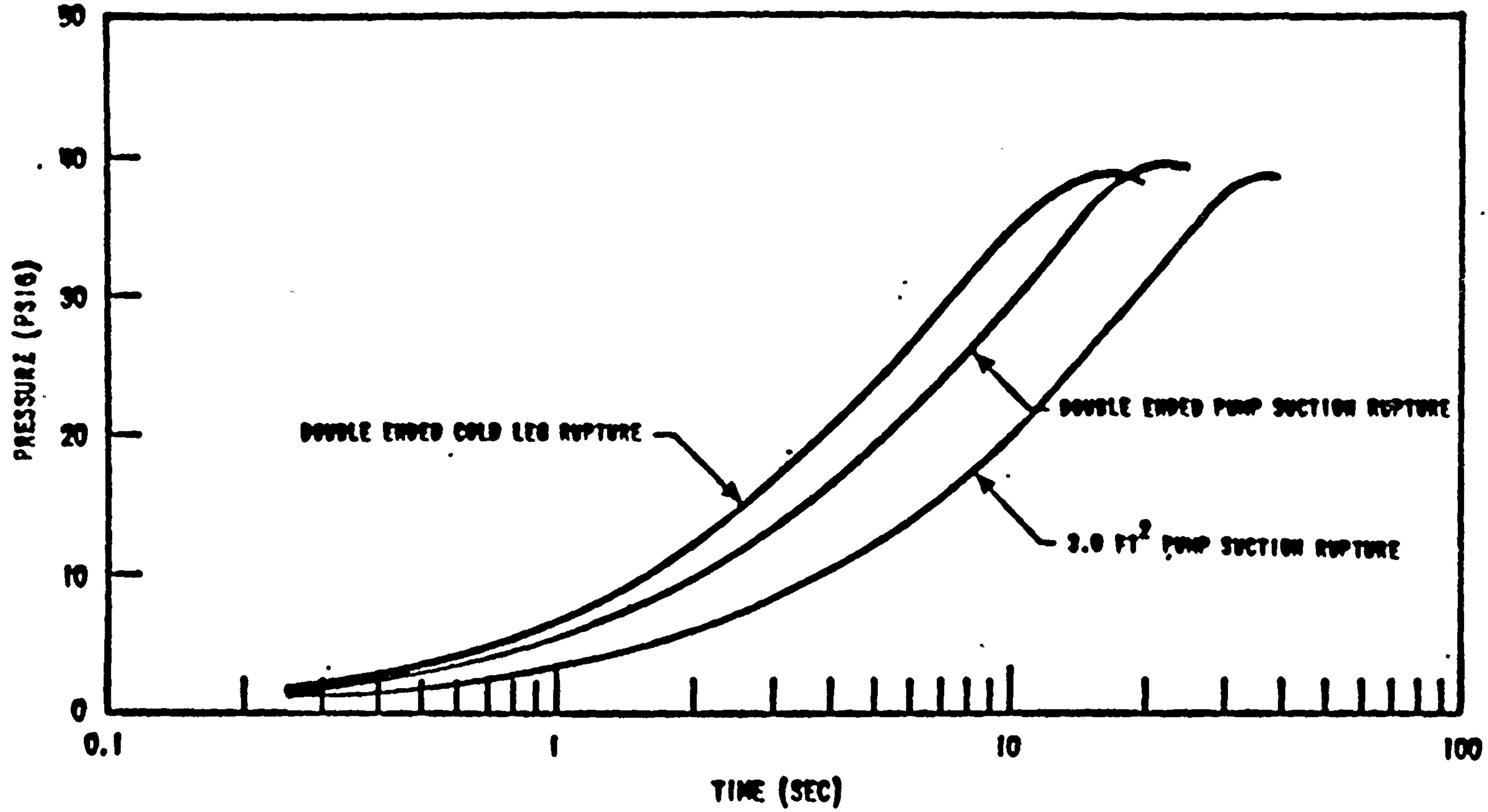

Figure 3. LOCA Curves

FSAR UPDATE
UNITS 1 AND 2, DIABLO CANYON SITE
CONTAINMENT PRESSURE TRANSIENTS BLOWDOWN PHASE