PSEG

Public Service Electric and Gas Company 80 Park Place Newark, N.J. 07101 Phone 201/430-7000

November 8, 1979

Director of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Mr. Olan D. Parr, Chief
Light Water Reactors Branch 3
Division of Project Management

Gentlemen:

CONTAINMENT PURGE AND PRESSURE-VACUUM RELIEF VALVES
NO. 2 UNIT
SALEM NUCLEAR GENERATING STATION
DOCKET NO. 50-311

Public Service Electric and Gas Company hereby submits the following information in response to your telephone request concerning the subject valves.

The design of the containment purge and pressure-vacuum relief valves considered the potential for debris that could become entrained in a post-accident environment lodging in the valves, thereby preventing the valves from performing their isolation function. In order to preclude this situation, the containment purge inlet valve and the pressure-vacuum relief valve, which are not connected directly to a filtered ventilation system inside the containment, are installed with the valve openings inside containment faced downward and protected by a 1-inch expanded metal mesh basket as illustrated in Attachment 1. It is our belief that this design provides assurance that debris will not become lodged in these valves and thereby prevent the valves from performing their isolation function.

The 10-inch pressure-vacuum relief valves were designed for a 5000 scfm flow rate with the valve in its full-open position (90 degrees). The maximum opening angle has been set at 60 degrees to ensure that the system design flow requirement of 2400 scfm as stated in the FSAR is met. Attachment 2 is an

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operations analysis, consisting of calculations which verify that the critical valve parts will sustain DBA-LOCA loads without damage and that the valve will close when the fluid dynamic forces are introduced. In addition, failure mode calculations were performed for both the 10-inch pressure-vacuum relief and the 36-inch purge valves which are also provided in Attachment 2.

Should you have any questions, please do not hesitate to contact us.

Very truly yours,

R. L. Mittl
General Manager -
Licensing and Environment
Engineering and Construction

Attach.

FH2 1/2

PSE&G

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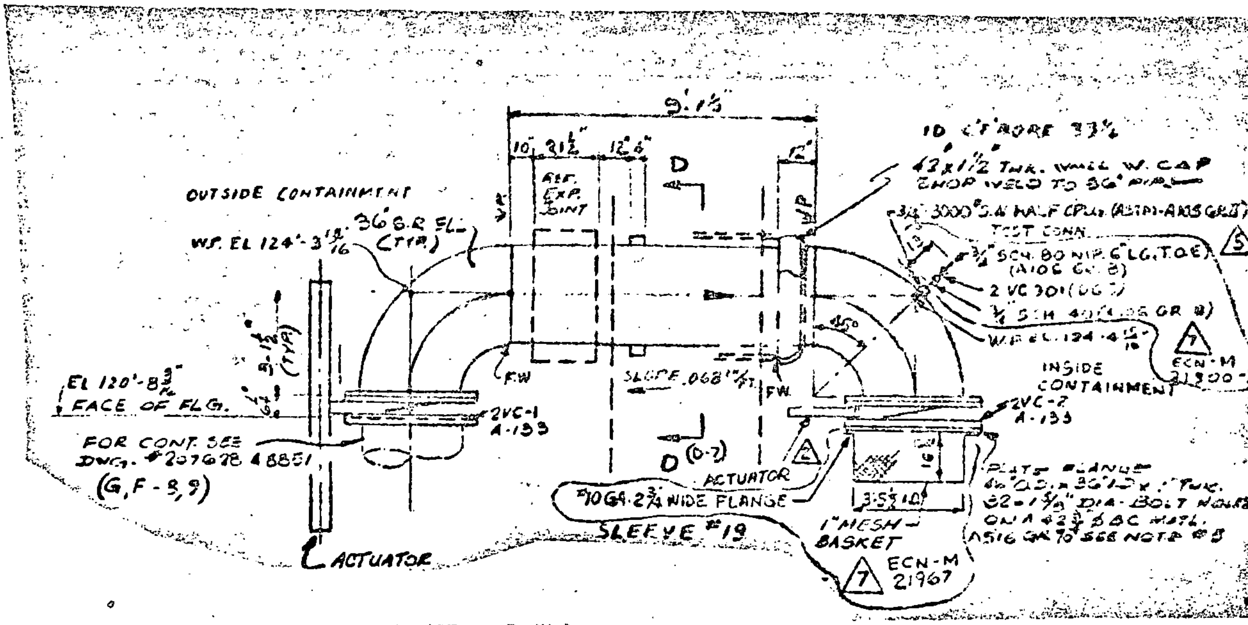
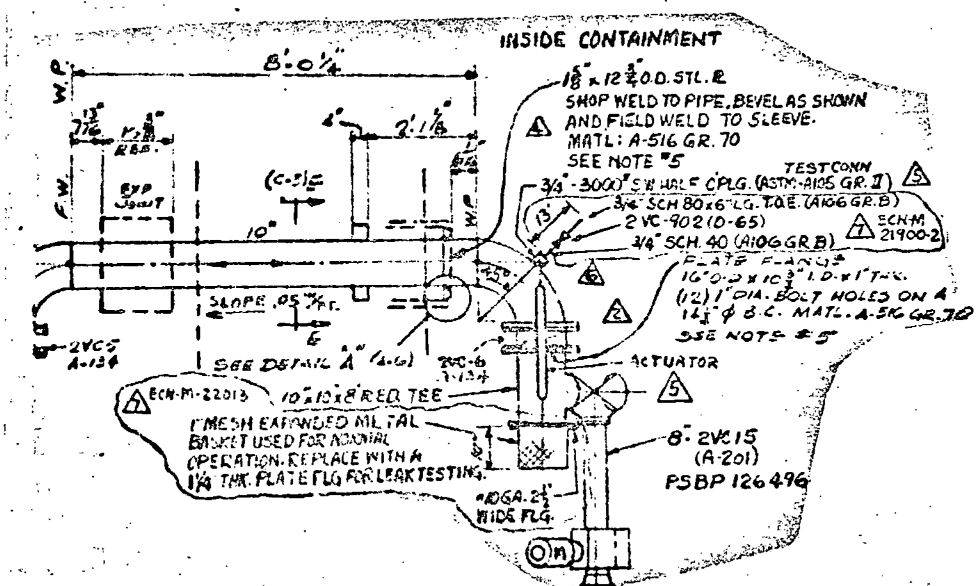
# ATTACHMENT 1




PURGE SUPPLY




PRESSURE-VACUUM RELIEF

SALEM NUCLEAR GENERATING STATION
NO. 2 UNIT-REACTOR CONTAINMENT
MISCELLANEOUS PIPING AT PENETRATION SLEEVES
ARRANGEMENT MECHANICAL

ATTACHMENT 2

MASONEILAN INTERNATIONAL, INC.

PUBLIC SERVICE ELECTRIC & GAS COMPANY

10" 32200 BUTTERFLY VALVES

BETTIS ACTUATOR MDL. 522C-SR-100

OPERATION ANALYSIS

The Bettis Robotarm is a spring opposed, pneumatic cylinder operator. During actuator loading, two 5" I.D. cylinders are pressurized to provide the necessary force to overcome the spring, valve friction, and dynamic loads. Although the spring force alone is sufficient to insure valve closure, an additional assist force is utilized to increase valve stroking speed. The assist force is caused by air loading one cylinder in the direction to close the valve. The assist force and loading force will not act at the same time.

Air for the assist force is obtained from the normal supply air. If the plant supply air fails, a backup accumulator tank will come on-line to air load the assist force.

A postulated LOCA would raise the containment pressure to 47 psig. Actuator loading will change. Calculations to determine the actuator forces during the various air loading configuration are shown on the attached sheets.

**Masoneilan**

CUSTOMER/PROJECT P. S. E&G
MNI REF. NO.
DATE 9/25/79 BY MB
SUBJECT 10" 32200 BUTTERFLY VALVES OPERATION ANALYSIS
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ACTUATOR LOADING MODES*

NORMAL SUPPLY PRESSURE = 80-100 PSIG

SPRING TORQUE
VALVE CLOSED = 3600 in-#
VALVE OPEN 60° = 9100 in-#

AIR ASSIST - ACTS WITH SPRING
80 PSI VALVE CLOSED = 3090 in-#
VALVE OPEN = 5340 in-#

100 PSI VALVE CLOSED = 3860 in-#
VALVE OPEN = 6675 in-#

LOADING FORCE - OPPOSES SPRING
80 PSI VALVE CLOSED = 6180 in-#
VALVE OPEN = 10680 in-#

100 PSI VALVE CLOSED = 7725 in-#
VALVE OPEN = 13350 in-#

NOTE: LOADING FORCE AND AIR ASSIST WILL NOT BE APPLIED TO THE ACTUATOR AT THE SAME TIME.

SUPPLY FAILURE - VALVE CLOSES WITH ACCUMULATOR

SPRING TORQUE - UNCHANGED

AIR ASSIST

(1) ACCUMULATOR PRESSURE = 80 PSIG MIN.
(2) ACCUMULATOR VOLUME = 739 $in^3$
(3) ASSIST VOLUME CLOSED = 85 $in^3$
(4) ASSIST VOLUME OPEN = 28 $in^3$

ASSIST PRESSURE OPEN $= \frac{P_I V_I}{V_T} = \frac{(80)(739)}{739+28} = 77$ PSIG

$P_I$: INITIAL ACCUMULATOR LOADING PRESSURE
$V_I$: ACCUMULATOR VOLUME
$V_T$: TOTAL VOLUME

CUSTOMER/PROJECT P. S. E. & G.

MNI REF. NO.

DATE 9/25/79 BY MB

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SUBJECT 10" 32200 BUTTERFLY VALVE OPERATION ANALYSIS

ASSIST PRESSURE CLOSED $= \frac{80(739)}{739+85} = 71$ PSI

VALVE OPEN

AIR ASSIST TORQUE = 5190 in-# @ 77 PSIG

VALVE CLOSED

AIR ASSIST TORQUE = 2240 in-#

LOCA

→ DURING A LOCA, LOADING PRESSURE IN THE ACTUATOR WILL NOT DROP TO 0 PSIG. THEREFORE, THE ACTUAL PRESSURE DIFFERENTIAL ACROSS THE PISTON FACE WILL DECREASE.

ASSUMING SPRING VOLUME IS OPEN TO CONTAINMENT, THE NEW FORCE BALANCE IS:

ASSIST PRESSURE OPEN = 77-47 = 30 PSI

ASSIST PRESSURE CLOSED = 71-47 = 24 PSI

VALVE OPEN

AIR ASSIST TORQUE = 2000 in-#

VALVE CLOSED

AIR ASSIST TORQUE = 925 in-#

SPRING AND ASSIST FORCE WILL STILL CLOSE VALVE. ESTIMATED VALVE STROKE TIME WILL INCREASE.

* NOTE: ACTUATOR LOADS SUPPLIED BY BETTIS CORPORATION, HOUSTON, TEXAS.

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CUSTOMER/PROJECT P.S.E.&G.

MNI REF. NO.

DATE 9/25/79 BY MB

SUBJECT 10" 32200 BUTTERFLY VALVE operation analysis

CHECKED BY

VALVE OPERATION

NORMAL SERVICE − $\Delta P$ = 2" of $H_2O$; use 1 PSI

open Position − 60°

$T_{REQ'D} = T_{OFF\text{-}BALANCE} + T_{SPRING} = 1\,PSI \times 76.2\,\frac{in\text{-}\#}{PSI} + 9100\,in\text{-}\#$

$T_{REQ'D} = 9176\,in\text{-}\#$

ACTUATOR LOADING TORQUE @ 80 PSI = 10680 in-#

WHEN CLOSED, THE PRESSURE ON THE UPPER AND LOWER PORTIONS OF THE VANE IS BALANCED, THEREFORE THE REQUIRED TORQUE IS THE SEATING LOAD OF THE VANE AGAINST THE LINER.

$T_{SEATING} = 1390\,in\text{-}\#$

THIS TORQUE IS SUPPLIED BY THE SPRING INITIAL

Min. $T_{SPRING} = 3600\,in\text{-}\#$

LOCA − $\Delta P$ = 47 PSI

FLOW ACROSS THE VANE WILL TEND TO CLOSE THE VALVE AND ASSIST THE SPRING IN FAILING THE VALVE CLOSED.

CUSTOMER/PROJECT P.S.E.&G.
MNI REF. NO.
DATE 9/25/79 BY MB
SUBJECT ALLOWABLE VALVE STRESSES AND LOADS FAILURE ANALYSIS
CHECKED BY

VALVE LOADS

(1) OPEN POSITION - 60°

LOADS CAUSED BY DYNAMIC TORQUE ON VANE FROM THE PRESSURE DROP ACROSS THE VALVE:

$\Delta P = P_1 - P_2$ ; $P_1$ = 47 PSIG - CONTAINMENT PRESSURE DURING LOCA

$\Delta P = 47 PSI$ ; $P_2$ = ATM = 0 PSIG

$T_C = 76.2 \frac{in\text{-}\#}{PSI} \times 47 = 3581 in\text{-}\#$ ; $T_C$: dynamic torque

(2) CLOSE POSITION

TWO LOADING MODES

(a) ACTUATOR TORQUE*
(TORQUE ON SHAFT AND SHEAR PINS)

$T_A = T_S + T_B$

$T_A$: TOTAL ACTUATOR TORQUE
$T_S$: SPRING TORQUE
$T_B$: ACTUATOR ASSIST TORQUE

$T_A = 3600 in\text{-}\# + 3860 in\text{-}\#$

$T_A = 7460 in\text{-}\#$

* SUPPLIED BY BETTIS CORPORATION HOUSTON, TEXAS

(b) OFF-BALANCE PRESSURE
(SHEAR ON SHAFT & BEARING LOAD)

$F = \Delta P (A)$

A: VANE AREA = $\frac{\pi}{4} d^2$

d: Vane diameter = 10.1"

$F = \Delta P \left(\frac{\pi}{4} d^2\right) = 47 \left(\frac{\pi}{4}\right) 10.1^2 = 3765 \text{ lbs}$

CUSTOMER/PROJECT P.S.E.&G.

MNI REF. NO.

DATE 9/25/79 BY MB

SUBJECT 10" 32200 BUTTERFLY VALVES FAILURE ANALYSIS

CHECKED BY

FAILURE MODES

A. OPEN POSITION – 60°

(1) SHEAR PINS 2-#5 17-4 MATERIAL

$T_{ALLOW} = \left(\frac{d}{1.13}\right)^2 \times D \times S \times N$

$T_{ALLOW}$: allowable torque
d: pin diameter = .266"
S: shear stress (2/3 of tensile) = 2/3 × 125000 PSI
D: shaft diameter = 1"
N: number of pins = 2

$T_{allow} = \left(\frac{.266}{1.13}\right)^2 \times 1 \times \frac{2}{3} \times 125000 \times 2$

$T_{allow} = 9235$ in-#

(2) SHAFT 1" dia. 17-4 shaft

$T_{allow} = \frac{D^3 S}{5.1} = \frac{1^3(2/3 \times 125000)}{5.1}$

$T_{allow} = 16340$ in-#

CRITICAL ELEMENT IN OPEN POSITION IS THE SHEAR PINS.

MIN. $T_{ALLOW} = 9235$ in-#

MAX VALVE LOAD IN OPEN POSITION & $T_c = 3581$ in-#

$MS = \frac{9235}{3581} - 1 = 1.58$

B. CLOSE POSITION

(1) SHAFT – TEAR OUT BY UPSTREAM PRESSURE

$F_{ALLOW} = SA_s \times 2$

$F_{allow}$: allowable shear on SHAFT
$A_s$: SHAFT CROSS SECTIONAL AREA

$F_{ALLOW} = \frac{2}{3}(125000) \times \frac{\pi}{4}(1)^2 \times 2 = 130900$ lbs

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CALC. NO.

CUSTOMER/PROJECT P.S.E.&G.

MNI REF. NO.

DATE 9/25/79 BY MB

SUBJECT 10" 32200 BUTTERFLY VALVES CHECKED BY

FAILURE ANALYSIS

$F_{ACTUAL} = 3765$ lbs @ 47PSI

$MS = \frac{130900}{3765} - 1 = \text{large}$

(2) BEARING LOAD - @ $\Delta P = 47PSI$

$\sigma_{Y_{ACT.}} = \frac{F_{ACTUAL}}{A_{BEAR}}$

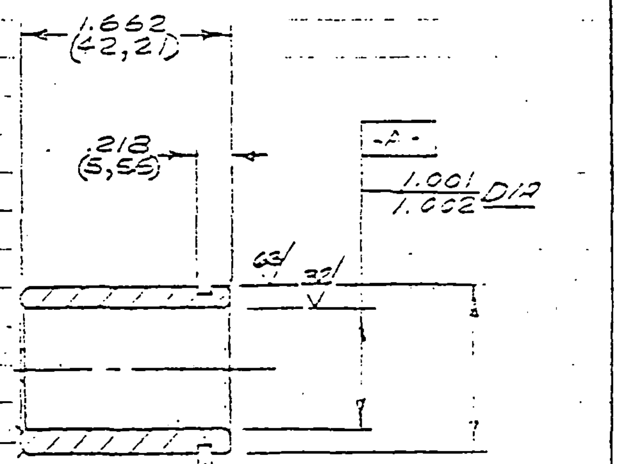
$\sigma_{Y_{act}}$: ACTUAL YIELD STRESS

$F_{ACTUAL}$: FORCE ON BEARING

$A_{BEAR}$: BEARING AREA

$\sigma_{Y_{ACT.}} = \frac{3765}{1.66 \times 1 \times 2} = 1134PSI$

$MS = \frac{65000}{3765} - 1 = \text{large}$




440C MATL.

$\sigma_{Y_{ALLOW}} = 65000PSI$

(3) SHAFT TORQUE

NON CRITICAL - USE SHEAR PINS

(4) SHEAR PINS

$T_{allow.} = 9235$ in-#

$T_{ACTUAL} = 7460$ in-# ; TOTAL ACTUATOR LOAD ON SEAT

$MS = \frac{9235}{7460} - 1 = .24$

CUSTOMER/PROJECT P.S.E.&G.
MNI REF. NO.
DATE 9/28/79 BY MB
SUBJECT 36" 32200 BUTTERFLY VALVE
CHECKED BY

FAILURE MODES

CLOSE POSITION ONLY

(1) SHAFT - TEAR OUT BY UPSTREAM PRESSURE
2" DIA. 17-4 MAT'L.

$F_{ALLOW} = SA_S \times 2$

$F_{ALLOW}$: ALLOWABLE SHEAR LOAD ON SHAFT
S: SHEAR STRESS (2/3 OF TENSILE)

$F_{ALLOW} = (2/3 \times 125000) \times 3.14 \times 2$

$A_S$: SHAFT CROSS-SECTIONAL AREA
$= \frac{\pi}{4}(2)^2 = 3.14 \text{ in}^2$

$F_{ALLOW} = 523000$ lbs

$F_{ACTUAL}$: ACTUAL FORCE ON VANE

$F_{ACTUAL} = \Delta P(A_V)$

$A_V$: VANE AREA (O.D. = 34.5")
$= \frac{\pi}{4}(34.5)^2 = 935 \text{ in}^2$

$F_{ACTUAL} = 47 \times 935 = 44000$ lbs

$\Delta P$: PRESSURE DIFFERENTIAL = 47 PSI

$MS = \frac{523000}{44000} - 1 = \text{large}$

(2) BEARING LOAD 440C MAT'L.

$\sigma_{Y ACTUAL} = \frac{F_{ACTUAL}}{A_{BEAR} \times 2}$

$\sigma_{Y ACTUAL}$: ACTUAL YIELD STRESS
$A_{BEAR}$: BEARING AREA (LENGTH × I.D.)
$= 3.35 \times 2 = 6.7 \text{ in}^2$

$\sigma_{Y ACTUAL} = \frac{44000}{13.4} = 3283$ PSI

$\sigma_{Y ALLOW}$: ALLOWABLE YIELD STRESS
$= 65000$ PSI

$MS = \frac{\sigma_{Y ALLOW}}{\sigma_{Y ACTUAL}} - 1 = \frac{65000}{3283} - 1 = \text{large}$

(3) SHAFT TORQUE

$T_{ALLOW} = \frac{D^3 S}{5.1}$

$T_{ALLOW}$: ALLOWABLE TORQUE
D: SHAFT DIAMETER = 2"

$T_{ALLOW} = \frac{2^3 (2/3 \times 125000)}{5.1}$

$T_{ALLOW} = 130700$ in-#

CUSTOMER/PROJECT P.S.E.&G
MNI REF. NO.
DATE 9/28/79 BY MB
SUBJECT 36" 32200 BUTTERFLY VALVE
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$T_{ACTUAL}$ = 77850 in-# @100 PSIG ASSIST
BETTIS ROBOTARM ACTUATOR
MOL. 746A-25R-41

$MS = \frac{130700}{77850} - 1 = .68$

(4) SHEAR PINS - 3 - #9 PINS; 17-4 MATERIAL

$T_{ALLOW} = \left(\frac{d}{1.13}\right)^2 \times D \times S \times N$

$T_{ALLOW}$: allowable torque
d: pin diameter = .539"
S: SHEAR STRESS (2/3 OF TENSILE)
= 2/3 × 125000 PSI
D: SHAFT DIAMETER = 2"
N: NUMBER OF PINS = 3

$T_{ALLOW} = \left(\frac{.539}{1.13}\right)^2 \times 2 \times \frac{2}{3} \times 125000 \times 3$

$T_{ALLOW}$ = 113760 in-#

$MS = \frac{113760}{77850} - 1 = .46$

CUSTOMER/PROJECT

MNI REF. NO.

DATE 9/26/79 BY MB

SUBJECT 10" 32200 BUTTERFLY VALVES
FAILURE ANALYSIS - $\Delta P = 60 PSI$

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VALVE LOADS

(1) OPEN POSITION - 60°

LOAD CAUSED BY DYNAMIC TORQUE ON VANE FROM PRESSURE DROP ACROSS THE VALVE.

$\Delta P = 60 PSI$ — $\Delta P$: PRESSURE DIFFERENTIAL

$T_c = 76.2 \frac{in-\#}{PSI} \times 60$ — $T_c$: dynamic torque

$T_c = 4572 \; in-\#$

(2) CLOSE POSITION

TWO LOADING MODES

(a) ACTUATOR TORQUE*
(TORQUE ON SHAFT AND SHEAR PINS)

$T_A = 7460 \; in-\#$ — $T_A$: TOTAL ACTUATOR TORQUE

* SUPPLIED BY BETTIS CORPORATION, HOUSTON, TEXAS

(b) OFF-BALANCE PRESSURE
(SHEAR ON SHAFT & BEARING LOAD)

$F = \Delta P (A_v)$ — F: ACTUAL TEAR OUT FORCE

$A_v$: VANE AREA (O.D. = 10.1")

$= \frac{\pi}{4}(10.1)^2 = 80.12 \; in^2$

$F = 60(80.12) = 4810 \; lbs$

CUSTOMER/PROJECT P.S.E&G.
MNI REF. NO.
DATE 9/26/79 BY MB
SUBJECT 10" 32200 BUTTERFLY VALVES
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FAILURE MODES

A. OPEN POSITION - 60°

(1) SHEAR PINS 2 - #5 PINS 17-4 MATERIAL

$T_{allow} = 9235$ in-# - see page 2.2

(2) SHAFT

$T_{allow.} = 16340$ in-# - see P. 2.2

CRITICAL ELEMENT IN OPEN POSITION IS THE SHEAR PINS.

$T_{allow} = 9235$ in-#

MAXIMUM VALVE LOAD IN OPEN POSITION IS THE ACTUATOR TORQUE

$T_{Act.} = T_L - T_S$

$T_{ACT.} = 13350 - 9100 = 4250$ in-#

$T_{ACT.}$: ACTUAL TORQUE
$T_L$: LOADING TORQUE = 13350 in-#; MAX.
$T_S$: SPRING TORQUE = 9100 in-#

$$MS = \frac{T_{ALLOW.}}{T_{ACT.}} - 1 = \frac{9235}{4250} - 1 = 1.17$$

B. CLOSE POSITION

(1) SHAFT - TEAR OUT BY UPSTREAM PRESSURE

$F_{allow} = 130900$ lbs

$F_{ACTUAL} = 4810$ lbs @ $\Delta P = 60$ PSI

$$MS = \frac{130900}{4810} - 1 = \text{large}$$

CUSTOMER/PROJECT P.S.E.&G.
MNI REF. NO.
DATE 9/26/79 BY MB
SUBJECT 18" 32200 BUTTERFLY VALVES
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(2) BEARING LOAD - @ $\Delta P = 60\,PSI$

$$\sigma_{Y_{ACT.}} = \frac{F_{ACTUAL}}{A_{BEAR.}}$$

$\sigma_{Y_{ACT.}}$: ACTUAL YIELD STRESS
$F_{ACTUAL}$: FORCE ON BEARING
$A_{BEAR.}$: BEARING AREA
= SEE PAGE 2.3
$\sigma_{Y_{ALLOW}}$: ALLOWABLE YIELD STRESS
= 65000 PSI - 440C

$$\sigma_{Y_{ACT.}} = \frac{4810}{1.66 \times 1 \times 2} = 1450\,PSI$$

$$MS = \frac{65000}{4810} - 1 = \text{large}$$

(3) SHAFT TORQUE
NON CRITICAL; USE SHEAR PINS

(4) SHEAR PINS

$$T_{ALLOW} = 9235\ in\text{-}\#$$

$$T_{ACTUAL} = T_S + T_A$$

$$T_{ACTUAL} = 7460\ in\text{-}\#$$

$T_S$: SPRING TORQUE ON SEAT
= 3600 in-#
$T_A$: ASSIST TORQUE ON SEAT
= 3860 in-# @ 100 PSI

$$MS = \frac{9235}{7460} - 1 = .24$$

CUSTOMER/PROJECT | MNI REF. NO.

DATE 9/28/79 BY MB

SUBJECT 36" 32200 BUTTERFLY VALVE
ΔP = 60 PSI

CHECKED BY

FAILURE MODES

(1) SHAFT - TEAR OUT BY UPSTREAM PRESSURE
2" DIA. 17-4 MATL.

$F_{ALLOW}$ = 523000 lbs - see page 3.1

$F_{ACTUAL}$ = 60 x 935 = 56100 lbs

$$MS = \frac{523000}{56100} - 1 = \text{large}$$

(2) BEARING LOAD 440C MATL.

$$\sigma_{Y_{ACTUAL}} = \frac{F_{ACTUAL}}{A_{BEAR} \times 2}$$ - see page 3.1

$\sigma_{Y_{ACTUAL}}$ = 4280 PSI

$$MS = \frac{65000}{4280} - 1 = \text{large}$$

(3) SHAFT TORQUE

$T_{ALLOW}$ = 130700 in - # - see page 3.1

$T_{ACTUAL}$ = 77850 in - # - see page 3.2

$$MS = \frac{130700}{77850} - 1 = .68$$

(4) SHEAR PINS

UNCHANGED FROM ΔP = 47 PSI

SEE PAGE 3.2